

# EXPERIMENTAL COURSE IN CHEMISTRY FOR HIGHER SECONDARY STAGE

LABORATORY MANUAL  
FOR  
TEACHERS

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EXPERIMENTAL COURSE

विद्यया ऽ मृतमश्नुते



एन सी ई आर टी  
NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्  
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## FOREWORD

The present laboratory manual for teachers of Classes XI and XII is a continuation of the Council's efforts to develop Chemistry experimental course for the higher secondary (+2) stage of the school education. Its purpose is to convey the need and philosophy of the course to the teachers and to provide them complete guidance for the laboratory work. In this course, apart from the experiments that are based on the theory course, some other experiments have been introduced. The relevant theory of these experiments will have to be discussed in the laboratory classes. Besides, projects and optional experiments have been introduced as a part of the laboratory work. It is hoped that this will lead to the introduction of some open-ended experimentation at the school level. Moreover, the present course has been designed to offer more flexibility in laboratory work and evaluation.

The first draft of the present laboratory manual was developed by the experimental group in Chemistry of the Department of Education in Science and Mathematics, NCERT. A number of subject experts and classroom teachers, who are acknowledged elsewhere, made significant contributions at the various stages of development and the finalisation of the manuscript. On behalf of the Council, I thank them all for their keen interest.

I should also like to express my thanks to Prof. A. K. Jalaluddin for initiating and guiding the project in the beginning and to the authors—Dr V N.P. Srivastava, Mr. B.L. Pandit, Dr Puran Chand and Dr. (Mrs) S B Malik—for their enthusiasm and hard work which have led to the completion of this project in a short period. Thanks are also due to the authorities and the staff of Regional College of Education, Ajmer (Rajasthan) for extending all facilities to hold the workshop for reviewing the present manuscript.

Suggestions for improvement of the 'Laboratory Manual' are most welcome.

SHIB K. MITRA  
*Director*

New Delhi  
April, 1979

National Council of  
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held at New Delhi in December, 1977**

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# INTRODUCTION

## 1.1 Need for the changes in chemistry experimental course

It is well known that the development of scientific attitude is one of the most essential components of education in the contemporary world. This implies familiarity with the scientific method and that in turn means doing something i.e. observing, measuring and describing. Traditional science bores or bewilders many pupils and undermines the confidence of many teachers. The work must be feasible, relevant and interesting. The method and the excitement of the search must be communicated. Undoubtedly, there are several constraints in the development of scientific attitude. Naturally, these constraints must be removed, accommodated, circumvented or overcome as far as possible. Keeping all these factors in view, a new course in experimental chemistry has been developed for classes XI and XII. This course is meant for those pupils who are desirous of pursuing science in their higher studies. The approach here should therefore be somewhat more sophisticated and has to be directed towards the practical and vocational aspects of science. The fundamental objective of this course is to develop the scientific attitudes and desired skills at this level.

The experiments have taken various forms and the emphasis on each experiment varies according to the teaching-learning objectives. Some experiments echo traditional investigations although the method and equipment may be radically different, others are qualitative in nature and hopefully lead to open ended investigations of quantitative nature. A third type of experiments are based upon environmental investigations.

Finally a number of experiments, investigations and surveys have been suggested as a part of experimental work which may be carried out at school or in the home environment.

An essential feature of the new laboratory course is the emphasis on project work. It provides the real thrill in the learning of science. Some of the major objectives of the project work are learning of new skills, development of scientific outlook, experiences in scientific research, personal experience of pursuing scientific discovery, formation of the habit of problem solving, arousing the spirit of enquiry, promoting innovative

attitude, providing a creative understanding for pupils, adding in developing mental alertness, bringing dynamism to the learning of science, sustaining interest in science, learning to write the scientific reports.

The choice of the project will also depend upon the facilities available in the school

The experiments emphasize the inter-relationship of various branches of science and provide a loose verticle integration between them. The present syllabus includes :

- (a) Core experiments,
- (b) Investigatory projects, and
- (c) Optional experiments.

While grouping these experiments, efforts have been made to include mainly those experiments, which will require a student to learn the basic skills, techniques and practices used in chemistry. The skills and experiences to be acquired by a pupil while performing an experiment have been spelt out so that he knows before-hand what is essentially expected from him after he has completed the investigations.

The importance of the proper selection and use of experimental tools, critical observations of different phenomena involved in an experiment and the various forms of representation of observations and measurements with a fair knowledge of the limitations of the methods used, rather than the accuracy of an experimental result, are highlighted.

Most of the experiments suggested are included in some form or the other in the syllabus of the Central Board of Secondary Education, New Delhi and other Boards of Secondary Education. A few unconventional activities have been included in the present syllabus with a view to encourage pupils to improvise experiments and design apparatus with very simple and readily available materials. It is expected that such activities will widen their interest in the subject and make them discover, to a limited extent, the methods of science. The titles and objectives of the conventional experiments have also been suitably modified to introduce a logical sequence in the operations to be performed in a given experiment. Such sequencing of ideas and activities is expected to help the students in designing experiments independently in future.

## **1.2 How to use laboratory manual in conjunction with the experimental sheets ?**

The objective of the practical work done by a pupil should be to apply his knowledge and skill gained in the laboratory to situations somewhat different from that of his laboratory. The real purpose of practical work should be to inculcate in a pupil—the ability to design an experiment, to

make observations methodically and to represent the outcome of the experiments logically leading to a conclusion with a genuine appreciation of its limitations. Unless a result or observation is absurd, the weightage on the result should be much less than that on the actual experimental operations, their recording and interpretation.

The present laboratory manual includes for each experiment the expected learning outcomes, materials required (apparatus and chemicals), procedure, remarks and precautions.

The experimental sheets have been developed on the process approach. These sheets should be used in conjunction with the laboratory manual because they contain all the possible solutions of the questions given in the experimental sheets. The experimental sheets are detachable, self explanatory and self-evaluative. Provision for grading the pupils on the basis of their performance has also been made in each of the experimental sheet. In some experiments, where previous instructions to the pupils are necessary, it is advisable to explain some of the theoretical aspects of the experiments before asking them to do the investigations.

The questions given in the experimental sheets are aimed at testing the pupils' understanding of the problems. Therefore, it is expected from the pupils to answer the questions according to their abilities. However, if the teachers feel that some questions are beyond the capacity of the learner he may explain the solutions after the students have finished their investigations. *The important precautions for each experiment should be emphasised to the pupils before they proceed for investigations.*

Alternative methods for performing the experiment in some cases have been mentioned in the laboratory manual and experimental sheets for the sake of flexibility. Teachers would be free to select any method which is suitable for their students.

Details of some sample investigatory projects have been mentioned in the laboratory manual. However, it is advisable for the teachers not to select only these projects. Freedom has been given to the teachers to select projects from their own subject area, inter-disciplinary areas or from the environment. Also the details of these projects should not be explained to the pupils before performing the investigation. Otherwise, the curiosity of the investigation will be lost. The choice of the project should depend on the facilities available in the school. Lack of laboratory facilities need not be made an excuse for not taking up project work, since many investigations can possibly be conducted in the environment by using commonly available apparatus and common laboratory items. However, if the school has better facilities in terms of laboratory and equipment, the teacher may encourage the pupils to undertake more sophisticated projects.

Appendices (I—IV) are attached at the end of the laboratory manual. They include Experimental Course in chemistry for classes XI & XII, background information about the investigatory projects, preparation of the common laboratory reagents, list of apparatus, glassware and chemicals required for the successful implementation of the course

It is hoped that the laboratory manual and experimental sheets if used properly by the teachers and pupils will improve the teaching-learning process in chemistry to a great extent. Pupils will also be able to understand the subject well and may be able to apply the acquired knowledge in the new situations.

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**EXPERIMENTS  
FOR  
CLASS XI**

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## EXPERIMENT NO. 1

*Duration : 2 Periods*

### Objective

Acquaintance of Chemistry Laboratory and basic laboratory techniques (bending, boring, sealing, cleaning of glass apparatus and burner).

### Expected learning outcomes

1. Familiarity with operations in Chemistry Laboratory.
2. Handling of glass apparatus, chemicals and other accessories.
3. Skill of bending and cutting of glass tubes, boring of corks, sealing of glass apparatus, cleaning of apparatus and burners.

### Materials required

(For each pupil or a group of pupils)

### Apparatus

Rubber cork, cork borer set, soda glass tube, test tube, brush triangular file, burner, sand paper and glass apparatus

### Chemicals

Wax and plaster of paris

### Procedure

#### (a) *Cork boring*

Place a rubber cork on the table with its small end in the upward direction. Hold the cork with the left hand and put the suitable borer dipped in water or in NaOH solution in the position where the hole is to be drilled. Hold the borer vertically and apply pressure gently while

rotating. Add a few drops of dilute NaOH solution into the boring tube to make the boring smooth and quicker

(b) *Bending of a glass tube and formation of a jet*

Mark a deep scratch on the glass tube at the desired length with the help of an edge of a triangular file\*. Break the glass tubing by applying pressure with the thumbs. Heat the freshly cut edge of the tube gently in the flame to make it smooth.

Take a tube of desired length. Put the tube on the flame and hold it on both the sides. Rotate it slowly until the portion which is kept on the flame becomes red hot and soft. Remove the tube from the flame and bend slowly at the desired angle.

Take a desired length of the glass tube and heat it in the middle by holding the tube on both the sides. Rotate the tube slowly until the portion which is kept on the flame becomes red hot and soft. Remove the tube from the flame and pull the ends apart slowly and smoothly until the centre has become narrow and then stretch into a fine jet, break the tube from the middle and make the jet uniform by rubbing it with a sand paper.

(c) *Cleaning of glass apparatus*

Prepare sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) solution or the solution of any washing powder. Keep the solution in a trough and dip the beakers, test tubes, porcelain dish, conical flask, measuring cylinder, etc., in it. Keep it as such for half an hour and then remove it from the solution. Scrub it with the test tube brush and rinse them with water.

The apparatus like burette, measuring flask, round bottom flask, etc., can be cleaned by rinsing them with sodium carbonate or washing powder solution. Remove the solution and rinse the apparatus with water.

In case the apparatus is greasy and is not cleaned by the above method, rinse the apparatus with 5% solution of NaOH or chromic acid solution. Keep the apparatus as such for some time and then pour off the solution into another container. Rinse the apparatus with water several times.

(d) *Cleaning of burner*

Heat the air regulator of the burner so that it may move freely. Remove

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\*The scratch should be made in one single stroke.

the burner tube and the ring from its base. Heat the nipple of the burner and remove the deposits with the help of a stove pin. After cleaning each part of the burner, reset the burner and attach it with the gas tube for further use.

*(e) Sealing of apparatus*

In order to seal the joints of the apparatus where leakage of gas is possible, use wax or plaster of paris.

**Remarks**

1. Boring of cork may be done from both the sides of the cork. For making two holes in the same cork, appropriate distance and the size of the borer should be kept into view.

2. In case pupils find difficulty in boring rubber corks, bark corks may be provided.

3. For bending and preparing a jet of the glass tube, pupils should be given glass tube of appropriate length (about 30 cm) so that no burns are received by the pupils.

4. Bending of a red hot glass tube should be done slowly. Otherwise uniformity in the shape of the tube will not be attained.

5. Chromic acid can be prepared by dissolving 5 g of  $K_2Cr_2O_7$  in 5 ml of water and then adding to it 100 ml of conc.  $H_2SO_4$  with constant stirring and cooling. It is better to provide prepared solution of chromic acid to the students.

**Precautions**

1. For sealing the joints, wax should be used only where heating is not required.

2. Filing and breaking of the glass tube should not be done very close to the face to avoid the injury.

*Caution :* Chromic acid is a very corrosive solution. Its spillage on cloth or skin should be avoided.

## EXPERIMENT NO. 2

*Duration : 6 Periods*

### Objective

Preparation and study of some important physical and chemical properties of gases

(chlorine, hydrogen chloride, sulphur-dioxide, carbon dioxide, hydrogen sulphide, hydrogen and oxygen)

### Expected learning outcomes

1. Skill of setting apparatus and mixing of reagents in appropriate proportions and conditions
2. Understanding of the chemical reactions through equations.
3. Verification of the properties of the gases.
4. Application of the properties of gases in salt analysis.

### Materials required

(For each pupil or a group of pupils)

Apparatus and chemicals required for the preparation of a particular gas should be selected from the following list.

### Apparatus

Woulf's bottle, conical flask (250 ml)/round bottom flask (250 ml), delivery tube, glass trough, beehive shelf, clamps, rubber corks with two holes and one hole, thistle funnel, boiling tubes/gas jars (with lids), burner, laboratory stand with clamps, tripod stand, wire gauze, wide mouth bottle, test tubes, deflagrating spoon, hard glass tube and beakers (250 ml).

### Chemicals

*Chlorine gas* : Manganese dioxide, conc hydrochloric acid, litmus paper, antimony powder, turpentine oil, filter paper, plaster of paris and yellow phosphorous.

*Hydrogen chloride gas* : Sodium chloride, conc. sulphuric acid, ammo-

mium hydroxide, silver nitrate, magnesium ribbon and red/blue litmus paper.

*Sulphur dioxide gas* : Copper turnings, conc. sulphuric acid, iodine solution, potassium permanganate and potassium dichromate solution, moist flowers, litmus paper (red/blue) and wooden splinters.

*Carbon dioxide gas* : Marble chips, dil. hydrochloric acid, lime water, magnesium ribbon, wooden splinter and red/blue litmus paper.

*Hydrogen sulphide gas* : Ferrous sulphide, dil. sulphuric acid, lead acetate paper, copper sulphate solution, cadmium nitrate solution, litmus paper (red/blue), wooden splinter.

*Hydrogen gas* . Granulated zinc, dil. sulphuric acid, plaster of paris, litmus paper, magnesium ribbon and wooden splinter.

*Oxygen gas* . Potassium permanganate, steel wool, sulphur, magnesium ribbon, charcoal, yellow phosphorous, litmus paper (red/blue) and wooden splinters.

## Procedures

### (a) Chlorine gas

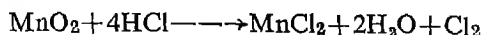
Molecular formula :  $\text{Cl}_2$

Molecular mass : 71

Take 2-3 grams of manganese dioxide ( $\text{MnO}_2$ ) in a conical flask and clamp the neck of the flask with the laboratory stand at appropriate height so that it may rest on the tripod stand. Place a wire gauze on the tripod stand. Close the flask with a rubber cork fitted with a thistle funnel and a delivery tube. Pour a few ml of conc.  $\text{HCl}$  through the thistle funnel so that the lower end of the funnel is dipped in the acid. Heat the flask and collect the gas in the boiling tubes or gas jars by the upward displacement of air and observe the colour of the gas, test its smell, heaviness, solubility, combustibility, effect towards litmus paper, bleaching action, etc. Study the reaction of the gas with antimony powder, yellow phosphorous, turpentine oil, etc.

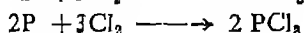
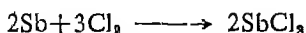
## Remarks

Reaction between manganese dioxide and hydrochloric acid can be written as :

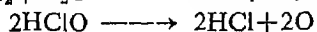
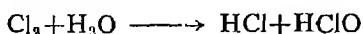


Chlorine is a greenish yellow gas, heavier than air. It has a pungent and suffocating smell. It is acidic in nature, soluble in water, non-combustible and does not support combustion. It has great affinity for hydrogen

therefore turpentine oil burns in it ( $C_{10}H_{16} + 8Cl_2 \rightarrow 16 HCl + 10C$ ). It oxidises antimony powder and yellow phosphorous which burn spontaneously when introduced in it. Chemical equations of the reaction are as follows .



It bleaches coloured flowers/cloth in the presence of moisture. Reactions may be represented as follows .



Nascent oxygen so obtained forms a colourless compound with the colouring matter.

Chlorine gas is used for disinfecting drinking water. Chlorine compounds such as bleaching powder are used for bleaching the coloured substances, dirt or stains, etc Industries make large use of chlorine and chlorine compounds.

### Precautions

1. Chlorine is a poisonous gas and it should not be inhaled.
2. Pupils should be instructed not to overheat the flask
- 3 It should be prepared in the open space.
4. The amount of acid added should be sufficient to cover  $MnO_2$  completely.

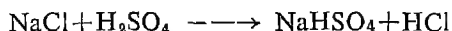
### (b) *Hydrogen chloride gas*

Molecular formula  $HCl$  Molecular mass : 36.5

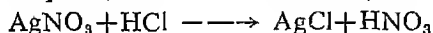
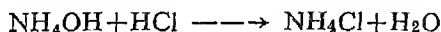
Take 2-3 grams of  $NaCl$  in a conical flask and clamp the neck of the flask with the laboratory stand at appropriate height. Close the flask with a rubber cork fitted with a thistle funnel and a delivery tube. Pour a few ml of conc  $H_2SO_4$  through the thistle funnel so that the lower end of the funnel is dipped into the acid. Heat the flask and collect the gas evolved by the upward displacement of air in a few boiling tubes or gas jars. Test the complete filling of the gas jar with the help of a moist blue litmus paper. Observe the colour of the gas and test its smell, solubility, combustibility, ability to support combustion heaviness and acidic/basic nature. Also study the reaction of the gas with  $NH_4OH$  and  $AgNO_3$  solutions separately.

**Remarks**

The reaction for the preparation of hydrogen chloride gas can be represented as ·



Hydrogen chloride is a colourless pungent smelling gas. It is heavier than air and soluble in water. It is neither combustible nor supporter of combustion. It turns moist blue litmus paper red and therefore it is acidic in nature. It gives white fumes with  $\text{NH}_4\text{OH}$  and a white precipitate with  $\text{AgNO}_3$  solution. The chemical reactions are as follows ·



It is used in colouring of cotton fabrics, leather goods and in medicine. In human body, it converts starch into glucose. It is used in the preparation of chlorine and chlorides.

**Precautions**

1. Since hydrogen chloride is a pungent smelling gas, the apparatus for its preparation should be air tight.
2. The gas should be preferably prepared in an open space or a fuming cupboard.

**(c) Sulphur dioxide gas**

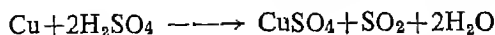
Molecular formula ·  $\text{SO}_2$

Molecular mass : 64

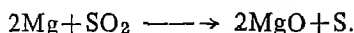
Take 2-3 grams of copper turnings in a conical flask/round bottomed flask. Close the flask with a rubber cork fitted with a thistle funnel and a delivery tube. Clamp the neck of the flask with the laboratory stand at appropriate height on a tripod stand having a wire gauze. Pour a few ml. of conc.  $\text{H}_2\text{SO}_4$  through the thistle funnel so that the lower end of the funnel is dipped into the acid. Heat the flask and collect the gas in a few boiling tubes or gas jars by the upward displacement of air. Test the complete filling of boiling tubes/gas jars with moist blue litmus paper. Close the mouth of the boiling tubes (or gas jars) with card board or glass discs. Observe the colour of the gas and test its smell, heaviness, combustibility, ability to support combustion, solubility and acidic/basic nature. Also study the reactions of the gas with  $\text{KMnO}_4$ , iodine and  $\text{K}_2\text{Cr}_2\text{O}_7$  solution.

**Remarks**

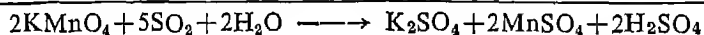
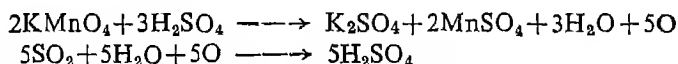
The reaction for the preparation of  $\text{SO}_2$  gas can be represented as :



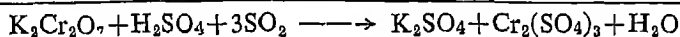
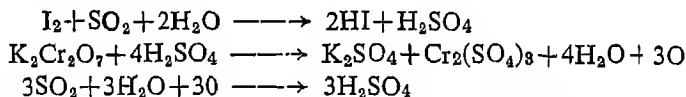
Sulphur dioxide is a colourless gas with suffocating odour. It is heavier than air and soluble in water. It is neither combustible nor supporter of combustion. However, a burning piece of magnesium ribbon continues to burn in it.



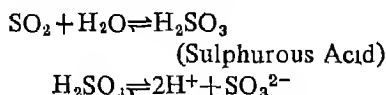
It is acidic in nature and therefore turns moist blue litmus paper red. It bleaches the colour of  $\text{KMnO}_4$  solution.



It also decolourises iodine and the yellow colour of  $\text{K}_2\text{Cr}_2\text{O}_7$  solution to green. The reactions are .



In all the above reactions sulphur dioxide acts as a reducing agent.  $\text{SO}_2$  dissolves in water and forms sulphurous acid.



Hydrogen ions are responsible for acidic nature of  $\text{H}_2\text{SO}_3$ .

**Precautions**

1. Since the gas is pungent smelling and poisonous in nature, the apparatus for its preparation should be completely air tight.
2. The students may be instructed to set up the apparatus in an open space or in a fuming cupboard.

(d) *Carbon dioxide gas*

Molecular formula .  $\text{CO}_2$       Molecular mass : 4

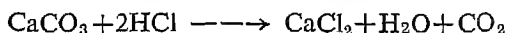


Take a few pieces of marble chips in a wide mouth bottle or a woulf's bottle. Close the mouths of the bottle with a rubber cork fitted with a thistle funnel and a delivery tube. Place the bottle on the working table. Pour a few ml of dilute hydrochloric acid through the thistle funnel so that the lower end of the thistle funnel is dipped into the acid.

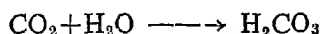
Collect the gas evolved by upward displacement of air in a few boiling tubes/gas jars. Test the complete filling of the gas with a burning splinter. Observe the colour of the gas and test its smell, heaviness, solubility, combustibility, ability to support combustion and acidic/basic nature. Also study the interaction of the gas with freshly prepared lime water, and a piece of burning magnesium ribbon.

### Remarks

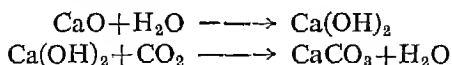
The reaction for the preparation of the gas can be represented as :



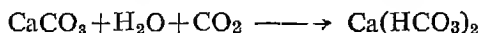
It is a colourless and odourless gas. It is soluble in water, heavier than air, non-combustible and non-supporter of combustion. It is acidic in nature. It reacts with water to form carbonic acid.



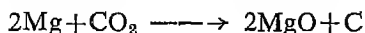
It reacts with freshly prepared lime water and forms a white precipitate of calcium carbonate.



On passing excess of  $\text{CO}_2$  gas in lime water the white precipitate dissolves due to the formation of  $\text{Ca(HCO}_3)_2$



Magnesium ribbon burns in it with dazzling light and forms  $\text{MgO}$ .



### Precautions

Sulphuric acid cannot be used for obtaining a continuous supply of  $\text{CO}_2$  gas for a longer duration because it forms insoluble  $\text{CaSO}_4$  which is deposi-

ted on marble chips. As a result of this, the reaction between the acid and the carbonate ceases after some time.

(e) *Hydrogen sulphide gas*

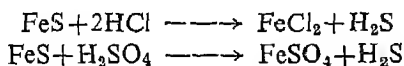
Molecular formula :  $\text{H}_2\text{S}$

Molecular mass . 34

Take a few pieces of iron sulphide in a test tube containing a hole at the bottom. Close the test tube with a rubber cork fitted with a delivery tube. Insert the test tube in a rubber cork and fit it in a wide mouth bottle (or conical flask) half filled with dilute sulphuric acid or dilute hydrochloric acid. Dip the lower end of the test tube in the acid so that iron sulphide pieces are completely dipped in the acid. Collect the gas evolved in the boiling tubes (or gas jars.) Test the complete filling of the gas by moist blue litmus paper. Observe the colour of the gas and test its smell, solubility, heaviness, combustibility, ability to support combustion and acidic/basic nature. Also study the reaction of the gas with lead nitrate, copper sulphate, cadmium nitrate and red and blue litmus solutions separately

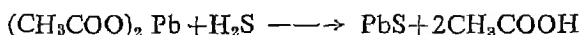
**Remarks**

The reaction between iron sulphide and hydrochloric acid or sulphuric acid can be represented as .

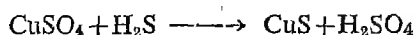


Hydrogen sulphide is a colourless and pungent smelling (like rotten eggs) gas. It is heavier than air and soluble in water. It is combustible but a non-supporter of combustion. It is acidic in nature.

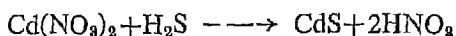
It reacts with lead acetate paper which turns black due to the formation of  $\text{PbS}$



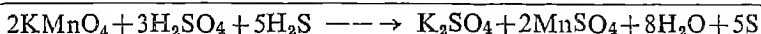
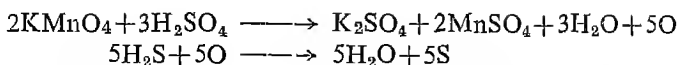
A black precipitate is obtained when  $\text{H}_2\text{S}$  gas is passed into the acidic solution of copper sulphate.



When  $\text{H}_2\text{S}$  gas is passed into a solution of cadmium nitrate, a yellow precipitate of cadmium sulphide is obtained.



It decolourises an acidic solution of  $\text{KMnO}_4$ . It has a reducing character.



### Precautions

1. After the gas has been prepared and collected the gas generating tube should be disconnected from the acid

2. For laboratory use,  $\text{H}_2\text{S}$  gas apparatus should be kept outside the laboratory. It is advisable to dip the delivery tube in water, while the apparatus is not in use.

3. Since the gas has to be used frequently in salt/mixture analysis, if possible, each pupil should be given separate tubes for passing  $\text{H}_2\text{S}$  gas. Pupils should also be instructed to wash the tube every time before using it.

### (f) *Hydrogen gas*

Molecular formula .  $\text{H}_2$

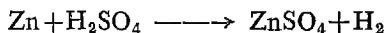
Molecular mass : 2

Take a few pieces of granulated zinc in a conical flask and place it on a working table. Close the mouth of the flask with a rubber cork fitted with a thistle funnel and a delivery tube. Pour a few ml of dilute sulphuric acid through the thistle funnel so that the lower end of thistle funnel is dipped in the acid and the zinc pieces are covered with the acid. Collect the gas by downward displacement of water in a few boiling tubes or gas jars. Cover the boiling tubes (or gas jars) with glass lids and keep them in inverted positions.

Observe the colour of the gas and test its smell, heaviness, solubility, combustibility, ability to support combustion, and acidic/basic nature. Also study the interaction of hydrogen gas with acidified  $\text{KMnO}_4$  solution

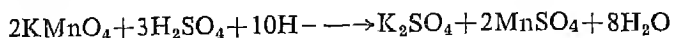
### Remarks

Zinc reacts with sulphuric acid and results in the formation of zinc sulphate and hydrogen gas.



It is a colourless, odourless gas which is lighter than air. It is insoluble in water. It is combustible but not a supporter of combustion. It is

neutral towards litmus paper, and therefore it is neither acidic nor basic in nature. Molecular hydrogen has no action on acidified  $\text{KMnO}_4$  solution. However if zinc piece is added to the test tube containing acidified  $\text{KMnO}_4$  solution the latter will be decolourised. This action is due to the formation of nascent hydrogen.



### Precautions

1. Hydrogen gas is highly combustible. Therefore the apparatus in which it is prepared should be air tight and kept far away from the burners. No flame should be brought near the apparatus, as there is likelihood of an explosion.
2. For testing the combustibility of the gas, a burning splinter should be introduced into the gas jar.
3. The gas should not be burnt at the end of the delivery tube.
4. The lower end of the thistle funnel should be completely dipped into the acid to avoid the leakage of hydrogen gas.

### (g) Oxygen gas

Molecular formula  $\text{O}_2$

Molecular mass : 32

Take 2-3 grams of potassium permanganate in a hard glass boiling tube and clamp it at an angle of nearly  $60^\circ$  with a laboratory stand. Take a delivery tube bent twice at an angle of about  $120^\circ$  in the opposite directions. Fix one end of this tube in the boiling tube with the help of a cork and the other end of this tube is dipped in water. Heat the boiling tube for some time and note that the bubbles are coming out of water. Collect the gas by downward displacement of water in boiling tubes (or gas jars).

Observe the colour of the gas and test its smell, heaviness, solubility in water, combustibility and ability to support combustion. Test the acidic/basic nature of the gas. Also perform the reaction with burning charcoal, magnesium ribbon, sulphur, phosphorus and steel wool.

### Remarks

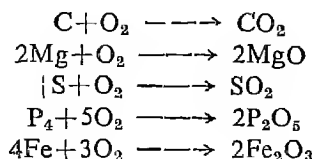
Potassium permanganate on heating gives oxygen gas.



It is a colourless, and odourless gas. It is heavier than air and slightly soluble in water. It is not combustible but supports combustion. It is

neither acidic nor basic in nature.

Charcoal, magnesium ribbon, sulphur, phosphorus and steel wool burn in oxygen and produce corresponding oxides. The reactions can be represented as follows :



### Precautions

Preparation of oxygen from  $\text{KClO}_3$  should be avoided as it requires strong heating. It is also an explosive material and therefore it is not advisable to use it.

## EXPERIMENT NO. 3

*Duration . 2 Periods*

### Objective

(a) Preparation of dilute solutions of sulphuric acid, hydrochloric acid and nitric acid of known concentrations.

(b) Reaction of dilute and concentrated acids on some metals (magnesium, zinc, copper and iron).

### Expected learning outcomes

1. Knowledge of making chemical calculations for preparing solutions.
2. Skill of handling acids.
3. Understanding of the interaction of acids with metals.
4. Knowledge of displacement reactions.
5. Skill of dilution and making up the desired volume.

### Materials required

(For each pupil or a group of pupils.)

**Apparatus**

3 conical flasks (500 ml), measuring cylinder (200 ml), beakers (250 ml), glass rod, test tubes, test tube brush, test tube stand, test tube holder and droppers.

**Chemicals**

Conc. hydrochloric acid, conc. nitric acid, conc. sulphuric acid, magnesium ribbon, granulated zinc, copper turnings and iron (filings/nails).

**Procedure***(a) Preparation of dilute solution of acids*

Note the strength of the concentrated hydrochloric acid, nitric acid and sulphuric acid (Approximate strength of these acids are . Hydrochloric acid = 10M (specific gravity 1.12), Nitric acid = 16 M specific gravity 1.2, Sulphuric acid = 18 M (specific gravity 1.98) Take 90 ml of concentrated hydrochloric acid in a conical flask marked and add to it 160 ml of distilled water slowly while continuously swirling the solution. Mark the flask as A. In a second flask marked B take 60 ml of nitric acid and add to it 190 ml of distilled water with the help of a measuring cylinder while continuously swirling the solution. Take 220 ml of distilled water in a conical flask marked C and add to it 30 ml of concentrated sulphuric acid with the help of a measuring cylinder. Cool the flask after each addition of the acid. It is advisable to keep the conical flask partly immersed in cold water. Repeat the process till all the acid is added to the solution. Shake the flask slowly. Calculate the strength of the three dilute solutions of acids so prepared.

**Remarks**

1. When 160 ml of water is added to 90 ml of concentrated hydrochloric acid, the solution so prepared would be approximately of strength 4 M
2. When 60 ml of concentrated nitric acid is added to 100 ml of water, the dilute solution of the acid so prepared would approximately be of strength 4 M.
3. When 30 ml of concentrated sulphuric acid is added to 220 ml of distilled water, the solution so prepared would approximately be of strength 2 M

**Precautions**

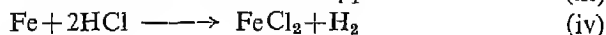
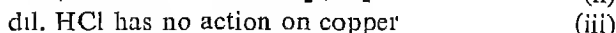
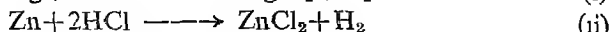
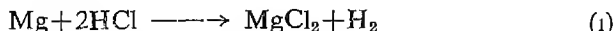
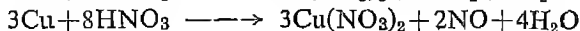
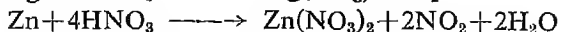
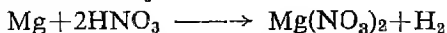
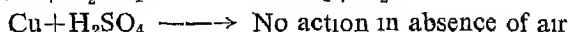
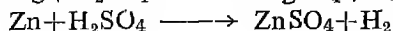
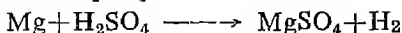
1. Acids being highly corrosive, pupils should be instructed to handle them with extreme care.
2. Pupils should wear aprons to protect their clothes.
3. While preparing dilute solutions of acids, pupils should be advised to pour acids into water and not water to acids. Special care should be emphasized in the case of sulphuric acid.

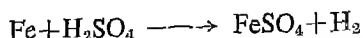
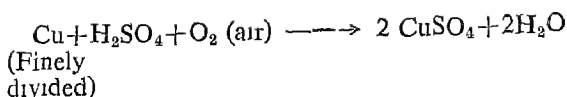
*(b) Reaction of dilute and concentrated acids on metals***Procedure**

Take eight marked test tubes (a, b, c, d, e, f, g, h). Fill one third of the test tubes a, b, c, d and e, f, g, h with dilute and concentrated hydrochloric acid respectively. Drop few pieces of metals (magnesium, zinc, copper and iron) one by one in each test tube a, b, c, d and e, f, g, h respectively. Observe the reactions. Test the gases evolved during the reactions. Observe the reaction product formed in all the test tubes. Arrange the results of the investigation in a tabular form. Repeat this process with nitric acid and sulphuric acid.

**Remarks**

1. When magnesium, zinc, copper and iron are dropped in cold dilute acids (hydrochloric, nitric and sulphuric) the following reactions take place.

*Reactions with dil. HCl**Reactions with dil. HNO<sub>3</sub>**Reactions with dil. H<sub>2</sub>SO<sub>4</sub>*



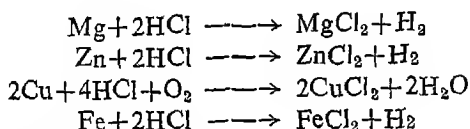
From the above reactions we find that metals like Mg, Zn and Fe react with dil. HCl in cold and produce hydrogen gas. This may be tested with the help of burning splinter whereas dil. HCl has no reaction on copper.

Cold dil.  $\text{HNO}_3$  reacts with Mg, and produces  $\text{H}_2$  gas. In case of Cu, nitric oxide is produced whereas in the case of Zn and Fe, nitrogen dioxide is produced. The brown fumes of nitrogen dioxide gas can be seen. It can also be tested with  $\text{FeSO}_4$  solution (brown ring is formed).

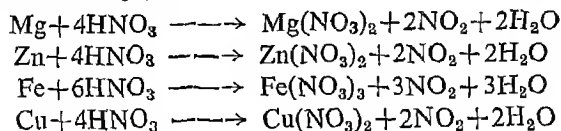
Magnesium, zinc and iron react with cold dil.  $\text{H}_2\text{SO}_4$  and produce hydrogen gas which can be tested with the help of a burning splinter. It reacts with copper in the presence of air (Oxygen) and produces  $\text{CuSO}_4$  and  $\text{H}_2\text{O}$ . In the absence of air dil.  $\text{H}_2\text{SO}_4$  has no action on Cu.

2. When magnesium, zinc, copper and iron are dropped in cold conc. acids (hydrochloric, nitric and sulphuric), the following reactions take place.

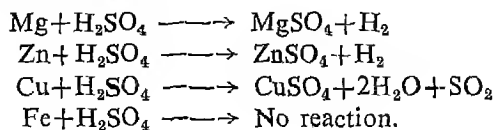
*Reactions with conc. HCl.*



*Reactions with conc  $\text{HNO}_3$  (cold)*



*Reactions with conc.  $\text{H}_2\text{SO}_4$  (cold)*



From the above reactions we find that metals like Mg, Zn and Fe react with conc. HCl and produce  $\text{H}_2$  gas, whereas with Cu it reacts in presence of oxygen of the air and produces  $\text{CuSO}_4$  and  $\text{H}_2\text{O}$ .

Magnesium, zinc, iron and copper react with conc.  $\text{HNO}_3$  and produce  $\text{NO}_2$  gas which can be tested with  $\text{FeSO}_4$  solution.

Zinc reacts with cold conc.  $\text{H}_2\text{SO}_4$  and produces  $\text{H}_2$  gas which can be tested with a burning splinter. Iron does not react with cold conc.  $\text{H}_2\text{SO}_4$ .



### Precautions

1. Acids being highly corrosive, students should be instructed to handle them with extreme care
- 2 Pupils should be instructed to wear aprons while working in the laboratory to protect their clothes
3. While studying the reactions of acids on metals, metals should be taken in the test tubes and only 2-3 ml of acids should be added.
- 4 For testing the gas liberated during the reactions of metals with acids, special care should be taken in the case of  $H_2$  gas.

## EXPERIMENT NO. 4

*Duration* · 2 Periods

### Objective

Preparation of pure crystals from impure samples.

### Expected learning outcomes



1. Skill of purifying impure substances.
2. Technique of growing crystals.
3. Identification of the geometrical shapes of some crystals.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Beaker (250 ml), glass funnel, tripod stand, porcelain dish, glass rod, burner and sand bath.

### Chemicals

Commercial variety of potash alum, copper sulphate, potassium nitrate, ferrous sulphate (from Kipp's waste), and distilled water.

### Procedure

Take 100 ml of distilled water in a beaker and prepare a saturated solution of potash alum/copper sulphate/potassium nitrate/ferrous sulphate at room temperature. Filter the solution and transfer the filtrate into a porcelain dish and heat it on a sand bath till  $\frac{3}{4}$ ths of the solvent is evaporated. Keep it undisturbed for cooling. After some time pour off the solution by decantation and dry the crystals between the two folds of a filter paper.

### Remarks

During preparation of pure crystals from their impure samples, various processes such as decantation, filtration and evaporation are involved. Crystals of potash alum are white in colour, copper sulphate are blue in colour, potassium nitrate are white in colour and ferrous sulphate are greenish white in colour.

Crystals from the dilute solutions can also be recovered by concentrating the solution and then cooling it at room temperature.

### Precautions

1. While concentrating the solution all the solvents should not be allowed to evaporate. Otherwise, good crystals will not be obtained.
2. The solutions should not be disturbed while they are being cooled.
3. After separating the crystals, pupils should be instructed to transfer the supernatant liquids into the appropriate labelled bottles. The pupils should be asked to submit dried samples of the purified crystals.

## EXPERIMENT NO. 5

*Duration : 2 Periods*

### Objective

Study of electrical conductivity of water and aqueous solutions of inorganic acids and bases, sugar, some salts and organic liquids

### Expected learning outcomes

1. Understanding of the electrical circuit and electrical nature of substances
2. Knowledge of conductor, poor conductor, non-conductor.
3. Understanding of dissociation of salts in solution.
4. Applying the knowledge of conductivity in classifying substances.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Beakers (150 ml —twelve), conductivity apparatus, 1 bulb (40 W/6V), 4 dry cells (1.5 V or mains) and glass rod

### Chemicals

Distilled water, dil. HCl, dil.  $\text{H}_2\text{SO}_4$ , Acetic acid, sodium hydroxide, ammonia solution, sugar solution, copper sulphate, sodium chloride, carbon tetrachloride, ethyl alcohol and benzene.

### Procedure

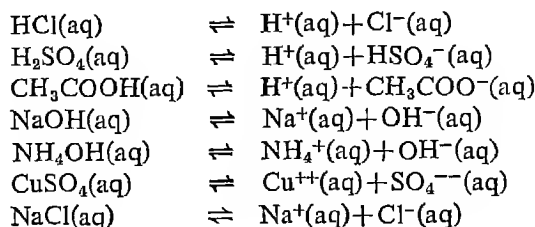
Take 12 marked beakers. Fill 1/4th of each beaker with  $\text{H}_2\text{O}$ , dil HCl, dil.  $\text{H}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOH}$ , NaOH,  $\text{NH}_4\text{OH}$  solution, sugar solution, carbon tetrachloride, ethyl alcohol, and benzene separately. Connect the conductivity apparatus with dry cell or mains and dip the terminals into these solutions one by one and observe the light intensity of the bulb in each case

Add distilled water to each of the beakers till one half of the beakers is filled with water. Again dip the terminals of the conductivity apparatus in these solutions one by one and note the intensity of the bulb in each case

### Remarks

When terminals of the conductivity apparatus are dipped in the above solutions, some conduct electricity (HCl,  $\text{H}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOH}$ , NaOH,  $\text{NH}_4\text{OH}$ ,  $\text{CuSO}_4$  solution, NaCl solution), some conduct electricity slightly (ethyl alcohol) and some do not conduct electricity at all (distilled water,  $\text{CCl}_4$ ,  $\text{C}_6\text{H}_6$ , sugar solution). These substances are classified as conductors,

poor conductors and non-conductors respectively. On dilution we find that the light intensity of the bulb increases in the case of conductors. This is due to increase in the ionization of the acids, bases and salt solutions. In the case of poor conductors, no change in the light intensity of the bulb is observed. Ionic equation for dissociation can be given as



In the case of acetic acid, on dilution the light intensity slightly increases and on further dilution it decreases. This is because acetic acid is a weak acid and does not ionise completely. On dilution number of ions per ml in the beginning increases and then decreases.

An improvised apparatus for measuring the conductivity can be made as shown in experimental sheet.

### Precautions

1. Electrodes should be washed every time before using.
2. While using the mains pupils should be instructed not to touch the open coils of the electrodes.
3. After measuring the conductivity of the organic liquids, they should be transferred to their respective bottles.
4. Students should be instructed not to mix the solution of one beaker into the another.

## EXPERIMENT NO. 6

*Duration* · 2 Periods

### Objectives

(a) Determination of pH of the following substances : (i) soils ; (ii) acids and bases of different dilutions ; (iii) vegetable and fruit juices.

(b) Study of pH change by common ion effect in case of weak acids and weak bases

### Expected learning outcomes

1. Skill of preparing extracts and juices.
2. Recognising the change in the colour of the indicator with varying pH of solutions.
3. Comparing the hydrogen ion concentration in different solutions.
4. Applying the common ion effect in preparing buffer solutions and salt mixture analysis.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Beakers (250 ml five), test tubes, funnel and filter paper.

### Chemicals

pH paper (or universal indicator), pH chart, distilled water, dil. HCl/dil.  $\text{H}_2\text{SO}_4$ , dil. NaOH, sodium acetate and acetic acid, ammonium chloride and ammonium hydroxide.

### Procedure

#### (a) *Determination of pH*

(i) Take about 10 grams each of two samples of the soil and thoroughly shake them with 100 ml of water in separate beakers (A and B). Filter the solutions. Take the filtrate in two test tubes marked A and B corresponding to the beakers A and B respectively. Add 2-3 drops of universal indicator in these test tubes and match the colour of the solution with the standard pH chart and determine the pH of the solutions.

(ii) Take 100 ml of distilled water in four beakers A, B, C and D. In beakers A and B add one drop and 1 ml of dil. HCl (shelf reagent) respectively. In beakers C and D, add one drop and 1 ml of NaOH solution (shelf reagent) respectively. Shake the solutions well. Take six marked test tubes (1, 2, 3, 4, 5 and 6). In test tubes 1 and 2 take 5 ml of solutions from beakers A and B separately. In test tube 3 take 5 ml of dil. HCl (shelf reagent).

In test tubes 4 and 5 take 5 ml of solutions from beakers C & D. In test tube 6 take 5 ml of NaOH solution (shelf reagent). Add 2-3 drops of universal indicator in all the six test tubes. Shake the test tubes and match the colour of the solutions with a standard pH chart. Determine the pH of these solutions

(iii) Extract the juice from lemon/orange/apple/pine apple/radish/potato, etc. Take 1 ml each of these juices in six marked test tubes (1, 2, 3, 4, 5 & 6) and add 2-3 drops of universal indicator in each test tube and shake. Match the colour of the solutions with the standard pH chart and determine the pH of the solutions.

**(b) pH change by common ion effect**

(i) *Acidic solution* : Take two boiling tubes A and B. Add about 10 ml of dil acetic acid solution to both the boiling tubes. Add about one gram of sodium acetate powder to the boiling tube B and shake it well. Add 3 drops of universal indicator solution to both the boiling tubes. Note down the colour of both the solutions and determine the pH values by comparing them with the standard pH chart.

(ii) *Basic solutions* : Take two boiling tubes A and B, add about 10 ml of ammonium hydroxide or powdered ammonium chloride to the boiling tube B and shake it well. Add 3 drops of universal indicator solution to both the boiling tubes. Note the colour of both the solutions and determine the pH value by comparing them with the standard pH chart

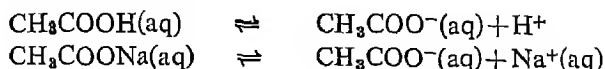
**Remarks**

1. Different soils have different pH and hence they may give different colours with universal indicator.

2. pH of acids and bases on dilution increases. In acidic solutions pH changes from 1 to 7 and in case of bases from 7 to 14.

3. Vegetables and fruit juices have different pH values due to the presence of different amounts of acids and bases in them.

4. When sodium acetate is mixed with a solution of acetic acid,  $\text{CH}_3\text{COO}^-$  acts as a common ion.



Addition of sodium acetate to acetic acid solution suppresses the ionization of acetic acid and this alters the concentration of  $\text{H}^+$  ions in the solution. As a result of this alteration in the concentration of  $\text{H}^+$  ions, pH of the solution will be changed.

5. When ammonium chloride is mixed with a solution of ammonium hydroxide,  $\text{NH}_4^+$  ions act as common ions.



Addition of  $\text{NH}_4\text{Cl}$  to ammonium hydroxide solution suppresses the ionization of ammonium hydroxide and this alters the concentration of  $\text{OH}^-$  ions in the solution. As a result of this alteration in the concentration of  $\text{OH}^-$  ions, pH of the solution will be changed.

### Precautions

1. Pupils should be instructed to add equal number of drops of the universal indicator in each test tube.
2. The colour of the solution should be matched carefully with the pH chart

## EXPERIMENT NO. 7

*Duration : 2 Periods*

### Objective

Determination of the melting point of a solid substance of low melting point (below  $100^\circ \text{C}$ ) by glass capillary tube method.

### Expected learning outcomes

1. Skill of setting apparatus for the determination of melting point.
2. Detection of the change of state i.e. from solid to liquid.
3. Skill of reading thermometer.
4. Comparing the melting point of the substance with the standard table of melting points.

### Materials required

(For each pupil or a group of pupils.)

**Apparatus**

Beaker (250 ml), thermometer ( $110^{\circ}\text{C}$ ), glass capillary tube, rubber band, laboratory stand with clamp and ring.

**Chemicals**

Distilled water, naphthalene/methyl oxalate/urea, and  $\alpha$ -naphthol.

**Procedure**

Take a capillary tube of approximate length of 5 cm, seal one end of the tube. Fill the substance (in powdered form) in the capillary tube (nearly 1 cm in length) by tapping. Tie the capillary tube with the help of a rubber band to the thermometer. Take a beaker half filled with water and dip the thermometer along with the capillary tube in the water so that the thermometer bulb and the portion of the tube containing substance is completely dipped in water.

Now start heating the beaker slowly and note the temperature when solid starts melting. Remove the burner and allow the water to cool. Note the temperature when solid starts reappearing. Take the average of the above two readings.

**Remarks**

For determining the melting point of the substance two temperatures should be noted i.e. the temperature while solid starts melting and the temperature when liquid starts solidifying. The average of these two temperatures would give the accurate melting point of the solid.

Water is used for determining the melting point of those substances which melt below  $100^{\circ}\text{C}$  (i.e. boiling point of water). In case of substances which melt above  $100^{\circ}\text{C}$  but below  $200^{\circ}\text{C}$  conc.  $\text{H}_2\text{SO}_4$  is used for the determination of the melting point. For substances which melt above  $200^{\circ}\text{C}$ , glycerine is used.

On heating, the kinetic energy of the solid molecules increases and when it exceeds the limit, the solid melts. In the liquid phase, the molecules get more opportunity to move freely.

**Precautions**

1. Crystalline substances should be first powdered and then filled in the capillary tube.



2. While tapping the capillary tube care should be taken to avoid the injuries.

3. After finishing the experiment pupils should be advised to keep the apparatus at the appropriate places.

(Note . Pupils should not be asked to prepare capillary tube. It should be supplied.)

## EXPERIMENT NO. 8

*Duration : 4 Periods*

### Objective

Study of the solubility of a solid substance in water at different temperatures and plotting of solubility curve.

### Expected learning outcomes

1. Understanding of the concept of saturated and unsaturated solutions
2. Understanding of the effect of temperature on the solubility of solid substances.
3. Skill of filling capillary tube and setting apparatus.
4. Skill of reading thermometer and plotting graphs.
5. Skill of finding amount of solid dissolved at a particular temperature from solubility curve.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Boiling tubes, (five), beaker (250 ml), thermometers ( $110^{\circ}\text{C}$ —two), laboratory stand with ring and clamps, tripod stand, wire gauze, and glass rod.

### Chemicals

Potassium nitrate/sugar/ammonium chloride and distilled water.

## Procedure

Take 5 ml of distilled water in four marked boiling tubes (A, B, C & D). Weigh 8, 9, 10, 11 grams of  $\text{KNO}_3$  and transfer it to boiling tubes A, B, C and D respectively.

Take a beaker half filled with water. Dip the boiling tube A in the water and heat the beaker slowly. Observe the temperature of the water regularly. Shake the boiling tubes from time to time. When solid of the boiling tube A is completely dissolved note the temperature and stop heating the water. Remove the boiling tube A from the beaker and dip a thermometer in the solution and allow it to cool. Note the temperature when solid starts reappearing and calculate the average temperature. Similarly repeat the process with boiling tube B, C and D and note the temperature for the disappearance and reappearance of the substances in these boiling tubes separately. Record the readings in the table and plot a graph between solubility in grams and average temperatures. From the graph calculate the solubility of  $\text{KNO}_3$  in grams/100 ml of water at  $50^\circ\text{C}$ .

## Remarks

1. For plotting a graph between solubility and temperatures, take the temperature on the X-axis and the solubility on the Y-axis.

2. From the solubility curve we can determine the solubility of a substance at any other temperature by simply selecting a point on the graph corresponding to that temperature and then reading the solubility corresponding to that point on the graph. The changes in the solubility of different substances with the increase in temperature can be determined. A mixture of two salts can be separated because of the difference in their solubilities at different temperatures.

3. The main difference between a saturated and an unsaturated solution can be stated as follows :

The solution in which no more solute can be dissolved at a fixed temperature is called a saturated solution. If solute is added, it settles down at the bottom of the container. The solution in which more solute can be dissolved at a fixed temperature and the solute particles do not settle at the bottom of the container is known as an unsaturated solution.

4. The solubility of a solute in a solvent at a temperature is constant. On changing the temperature the solubility changes.

If more solvent is added to a saturated solution at a particular temperature, the solution becomes unsaturated and more solute can be dissolved in it.

### Precautions

1. Pupils should be instructed to read the thermometer accurately.
2. While plotting a graph, appropriate scale should be selected.
3. After performing the experiment, the pupils should be advised to keep the apparatus at appropriate places.

## EXPERIMENT NO. 9

*Duration : 2 Periods*

### Objective

Determination of the calorific value of combustible liquids/solids (methylated spirit/kerosen oil/mustard oil/wax/camphor)

### Expected learning outcomes

1. Skill of setting apparatus for the determination of calorific value.
2. Understanding of the calorific value of fuels.
3. Understanding of the appropriate selection of fuels.
4. Knowledge of the principles of transfer of heat energy.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Candle/spirit lamp, laboratory stand with clamp, thermometer ( $110^{\circ}\text{C}$ ), metallic container, beaker (500 ml), physical balance and glass rod.

### Chemicals

Candle/kerosen oil/mustard oil/methylated spirit/camphor

### Procedure

Weigh a candle ( $m_1$ ) and place it in the middle of a tin container. Weigh an empty beaker ( $m_2$ ). Fill this beaker half with water and weigh again

( $m_3$ ). Calculate the mass of water taken in the beaker ( $m_3 - m_2$ ). Dip the metallic container having a candle into the beaker containing water. Note the temperature of the water ( $t_1^\circ\text{C}$ ). Burn the candle and stir the water until temperature of water rises to about  $5^\circ\text{C}$  above  $t_1^\circ\text{C}$ . Blow out the candle flame. Stir the water while watching the thermometer reading and record the final temperature ( $t_2^\circ\text{C}$ ) of water. Calculate the change in temperature ( $t_2 - t_1$ )  $^\circ\text{C}$ . Weigh the candle again ( $m_4$ ) and calculate the mass of the candle burnt ( $m_1 - m_4 = W$ ). Calculate the energy in kcals which has gone to water in the form of heat by the expression  $\frac{W \times t}{1000}$  kcals.

Heat of combustion per mole of the fuel burnt can be calculated from the expression  $\frac{W \times t}{1000 \times M}$  kcals per gm of substance.

Where  $M$  is the molecular mass of the substance.

### Remarks

1. The errors in the experiment may occur due to heat lost by beaker.
2. Heat is lost by the container (tin box) from upper side as well as the portion of the container which is not dipped in water.

There is no need to calculate the exact calorific value. The pupils should get the idea of setting the apparatus and performing the experiment. During burning of candle, combustion of paraffin wax with oxygen takes place to give carbon dioxide, water and heat. If we observe the inside of the tin container some water drops can be seen. It is due to evaporation of some water molecules, which occurs due to the liberation of heat during the combustion. This of course introduces some error in the observation of the rise in temperature, but it is unavoidable and not a major error.

### Precautions

1. Pupils should be advised to burn the candle after dipping the tin container into the water.
2. While weighing the candle, wax deposited on the sides of the candle and bottom of the tin container should be taken into account.
3. Thermometer reading should be taken accurately and if possible thermometer of  $0.1^\circ\text{C}$  graduation should be provided.

## EXPERIMENT NO. 10

*Duration . 2 Periods*

### Objective

Study of the shift in equilibrium between ferric ions and thiocyanate ions by increasing the concentration of either of them

### Expected learning outcomes

1. Understanding of the equilibrium point and comparison of the intensity of colour of the solutions.
2. Understanding of the reversible reaction and shift in the equilibrium point.
3. Knowledge of equilibrium constant.
4. Application of the knowledge of equilibrium constant in mixture analysis.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Test tubes (three), boiling tube, beaker (250 ml), dropper, test tube stand and glass rod.

### Chemicals

Ferric chloride solution and ammonium thiocyanate solution.

### Procedure

Take a boiling tube marked A and three test tubes marked B, C and D. Fill 1/4th of the boiling tube A with water and add 10 drops of  $\text{FeCl}_3$  solution in it. Divide this solution into three equal parts and pour them in test tubes B, C and D. Add 5 drops of KCNS solution in each test tube and shake well. Add 10 drops of water, ferric chloride and potassium thiocyanate in test tubes B, C and D respectively and shake. Compare the intensity of colours in test tubes C and D with test tube B.

**Remarks**

On the addition of excess of  $\text{FeCl}_3$ ,  $\text{Fe}^{3+}$  concentration increases and hence the formation of  $\text{Fe}(\text{CNS})^{2+}$  ions also increases resulting in the deepening of the colour and shifting the reaction in forward direction. Similarly on the addition of excess of  $\text{CNS}^-$  ions the formation of  $\text{Fe}(\text{CNS})^{2+}$  increases, thus shifting the reaction in the forward direction.

Hence in both these cases intensity of the colour will increase as compared to the original colour (test tube B).

Pupils should be provided approximately molar solutions of ferric chloride and  $\frac{M}{5}$  solution of  $\text{KCNS}$ . If the change is not distinguishable, a more dilute solution  $\left(\frac{M}{20}\right)$  of  $\text{FeCl}_3$  may be used.

As it is a qualitative experiment, we do not expect the exact results from the students and so they may be assessed on the basis of their performance.

**Precautions.** Students should be advised to see the colour of the solution from the side of the test tube. It will be better if all the three test tubes are seen in the diffused sunlight so that the differences in colour can be seen easily.

**EXPERIMENT NO. 11**

*Duration : 4 Periods*

**Objective**

Preparation of standard solutions of oxalic acid and sodium carbonate.

**Expected learning outcomes**

1. Skill of chemical calculation for preparing standard solutions.
2. Skill of handling a chemical balance.
3. Skill of making standard solutions of acids and bases.
4. Application of the knowledge in volumetric analysis.

**Materials required**

(For each pupil or a group of pupils.)

**Apparatus**

Funnel, measuring flask (250 ml), chemical balance, weight box and weighing tube.

**Chemicals**

Oxalic acid (A.R.) and sodium carbonate (A.R.)

**Procedure***(a) Preparation of a standard solution of oxalic acid :*

Molecular mass of oxalic acid = 126 grams.

From the molecular mass of oxalic acid, calculate the amount of oxalic acid required for  $\frac{M}{10}$  solution in 250 ml  $\left( \frac{126}{10} \times \frac{250}{1000} = 3.1500 \text{ gms approx} \right)$

Weigh the empty weighing tube (I weighing) by using a chemical balance. Take approximate amount of the substance as calculated above in the weighing tube and weigh up to the four decimal places (II weighing) by using chemical balance.

Take a measuring flask (250 ml). Transfer the substance from the weighing tube into the flask with the help of a funnel. Close the lid of the weighing tube and weigh it again accurately up to the four decimal places (III weighing). Calculate the exact amount of the substance transferred into the measuring flask by subtracting III weighing from the II weighing. Wash the funnel several times with distilled water without removing the funnel from the flask by using wash bottle. While washing the funnel, water should be added in small amounts so that it may not exceed  $\frac{1}{4}$ th volume of the flask. Swirl the flask till solid is dissolved completely. Make up the solution up to the mark and shake it by closing the stopper of the flask.

*(b) Preparation of a standard solution of sodium carbonate :*

Molecular mass of sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) = 106 grams.

From the molecular mass of sodium carbonate, calculate the amount of sodium carbonate required for  $\frac{M}{10}$  solution in 250 ml

$$\left( \frac{106}{10} \times \frac{250}{1000} = 2.6500 \text{ grams} \right)$$

Now prepare a solution of sodium carbonate by the method as mentioned in step (a)

### Remarks

1. While weighing, weights should be kept on the right hand side and weighing tube on left hand side of the balance. Rider should be kept on the right hand side only. It is better to weigh empty weighing tube first approximately and then weigh with the substance accurately upto four decimal places. Weigh the weighing tube accurately upto four decimal places after transferring the substance into the measuring flask.

2. The method of washing the weighing tube for transferring the substance should be avoided.

3. While making the solution up to the mark water should be added dropwise.

### Precautions

1. While weighing pupils should be instructed not to spill the substance on the pan.

2. The knob of the balance should be rotated gently.

3. After weighing pupils should be advised to keep the weights in the weight box at their appropriate places.

4. While transferring the substance into the funnel, weighing tube should be brought very close to the edge of the funnel and the substance be transferred gently.

## EXPERIMENT NO. 12

*Duration : 6 Periods*

### Objective

Study of acid-base single titration (i.e. oxalic acid and sodium hydroxide/hydrochloric acid and sodium carbonate).

### Expected learning outcomes

1. Skill of handling burette and pipette.
2. Skill of measuring and reading volumes, titrating and finding out the end point.



- 3 Skill of using indicators in acidic and alkaline medium.
- 4 Skill of chemical calculations.
- 5 Knowledge of chemical reaction involved during titration.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Burette (50 ml), pipette (25 ml) conical flasks (250 ml—two), burette stand, funnel and white glazed tile.

### Chemicals

Oxalic acid (A.R.), sodium hydroxide, sodium carbonate (A.R ) hydrochloric acid, phenolphthalein and methyl orange indicators.

### Procedure

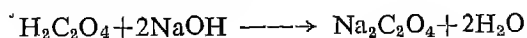
*(Estimation of sodium hydroxide by its titration against standard oxalic acid solution )*

Rinse a clean burette with the given NaOH solution. Fit the burette on the stand and fill it (nearly up to the zero level) with NaOH solution. Remove the air gap from the burette tip by running the solution from the burette nozzle and note the initial reading.

Pipette out 25 ml of oxalic acid solution in a conical flask. Add 2-3 drops of phenolphthalein indicator to it. Titrate the acid with sodium hydroxide solution until a very faint permanent pink colour is obtained. Repeat the titration until two concordant readings are obtained. Calculate the strength of the NaOH solution by using the equation  $a_1M_1V_1 = a_2M_2V_2$  where  $a_1$  and  $a_2$  stand for the acidity and basicity of the acid and the alkali respectively.  $M_1V_1$  and  $M_2V_2$  stand for the molarities and volumes of the acid and the alkali respectively.

### Remarks

1. Oxalic acid reacts with sodium hydroxide and results in the formation of sodium oxalate and water.



2. During titration only a few ml of solutions should be added from the burette with swirling the conical flask so that the reactants may react

easily and accumulation of a large amount of the reagent at one place may not occur. This is known as homogeneous mixing

3 Two concordant readings are essential for the titration because this will avoid the error in the titration

4 Average of the readings should not be taken, otherwise this may cause error in the calculation of the strength of the unknown solution

5 In this titration, the sodium hydroxide reacts completely with the whole amount of oxalic acid present in the solution and a little excess of the sodium hydroxide indicates that the end point has reached.

6 We have to calculate the strength of the solution in g/litre because this gives us an idea about the amount of substance dissolved in one litre of the given solution. This is taken as a standard measure for determining the strength of the solution.

7 The inter-relationship between molarity (M) and normality (N) of oxalic acid and sodium hydroxide is as follows

(a) Oxalic acid( $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ )

Molecular mass=126.07

Equivalent mass=63.04

i.e.  $M=2N$

(b) Sodium hydroxide (NaOH)

Molecular mass=40

Equivalent mass=40

i.e.  $M=N$

### Precautions

1 Pupils should be instructed to wash the burette after finishing the titration as the NaOH solution left in the burette may jam the stop cork of the burette.

2. Pupils should be advised to add NaOH solution dropwise near the end point so that it may be located easily and correctly.

3. Pupils should be instructed to pipette out the solution accurately upto the mark and should pour the solution through the walls of the titration flask. They should not blow the pipette for the last drop of the solution. In the end they should only touch the tip of the pipette to the walls of the flask two or three times gently.

4. While pipetting the solution, the nozzle of the pipette should be completely dipped in the solution otherwise some of the solution may be got sucked into the mouth.

5. While taking readings from the burette white paper should be used as an antiparallax card to read the correct reading.

6 While noting the readings from the burette, the lower meniscus should be taken in case of colourless solutions. In case of coloured solutions, the upper meniscus should be taken

7. Calculations for determining the strength of the solutions must be made up to the fourth place of decimals.

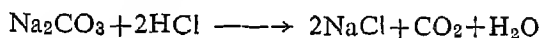
(b) *Titration of sodium carbonate and hydrochloric acid.*

### Procedure

Repeat the procedure as mentioned in the earlier titration, except that in this case HCl solution should be taken in the burette and  $\text{Na}_2\text{CO}_3$  solution in the titration flask. In this case methyl orange is used as an indicator.

### Remarks

1. In this titration HCl reacts with  $\text{Na}_2\text{CO}_3$  and results into the formation of NaCl (salt),  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .



2 The inter-relationship between molarity and normality of hydrochloric acid and sodium carbonate is as follows :

- (a) Hydrochloric acid (HCl)  
Molecular mass = 36.46  
Equivalent mass = 36.46  
i.e.  $M = N$ .
- (b) Sodium carbonate ( $\text{Na}_2\text{CO}_3$ )  
Molecular mass = 105.99  
Equivalent mass = 53.00  
i.e.  $M = 2N$

## EXPERIMENT NO. 13

*Duration : 4 Periods*

### Objectives

Study of the heat of neutralization of sodium hydroxide with hydrochloric acid.

**Expected learning outcomes**

1. Skill of handling calorimeter and other volumetric apparatus.
2. Knowledge of exothermic reactions.
3. Understanding of acid-base reactions and its heat of neutralization.
4. Skill of calculating total amount of heat produced during neutralization.

**Materials required**

(For each pupil or a group of pupils.)

**Apparatus**

Beakers (250 ml—three), beaker (500 ml—one), thermometer (110° C) and glass rod.

**Chemicals**

1 M HCl solution (100 ml), and 1 M NaOH solution (100 ml).

**Procedure***(a) Water equivalent of a calorimeter*

Take a marked beaker A of 250 ml capacity and weigh it ( $m_1$ ). Take 100 ml of water in beaker A and weigh it again ( $m_2$ ). Note the temperature ( $t_1^\circ\text{C}$ ) of water

Take 100 ml of weighed hot water ( $m_3$ ) of temperature nearly  $50\text{--}60^\circ\text{C}$  ( $t_2^\circ\text{C}$ ). Pour the hot water into the cold water of the beaker. Stir the solution and note the final temperature ( $t_3^\circ\text{C}$ ). Calculate the water equivalent of the beaker by using the following equation :

$$(m_2 + W)(t_3 - t_1) = m_3(t_2 - t_3)$$

where W is the water equivalent of the calorimeter.

*(b) Heat of neutralization*

Take two marked beakers B and C of 250 ml capacity and one beaker marked D of 500 ml capacity.

Take 100 ml of 1M NaOH solution ( $V_1$ ) in beaker B and 100 ml of 1M HCl solution ( $V_2$ ) in beaker C. Note the temperature of both the solutions ( $t_1^\circ\text{C}$ ). Place beaker B on a wooden block kept in beaker D (the beakers should not touch each other) Pour HCl solution from the

beaker C to the beaker B containing NaOH solution. Stir the solution rapidly and note the final temperature ( $t_2^\circ\text{C}$ ). Calculate the rise in temperature  $(t_2 - t_1)^\circ\text{C}$ . Calculate the total amount of heat produced during neutralization by using the expression :

$$(V_1 + V_2 + W) \times (t_2 - t_1) \text{ calories.}$$

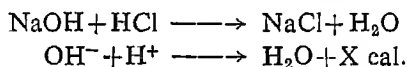
### Remarks

When one gram mole of solid/liquid substance is dissolved in a fixed quantity of water, the heat evolved or absorbed is known as "heat of solution".

When a solution is diluted further by addition of solvent in it, the heat produced/absorbed is known as "heat of dilution".

When a dilute solution of an acid is added to a dilute solution of a base, neutralization reaction takes place with the formation of salt and water. Heat evolved or absorbed during this process for the formation of one mole of water is known as "heat of neutralization".

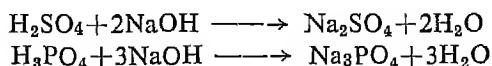
The neutralization reaction between NaOH and HCl can be given as :



2. During the determination of the heat of neutralization, the water calorimeter is used. Here beaker B is kept in beaker D. The heat absorbed by the beaker B is essential to determine for accurate calculation of the heat of neutralization. The heat absorbed by the beaker B is known as the water equivalent of the beaker.

3. In this experiment, air gap between the two beakers (B and D) is used as an insulating material. Therefore some heat loss may take place due to the difference in temperatures of the beaker B and the surrounding air.

4. For the neutralization of polybasic acids eg,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_3\text{PO}_4$ , etc. more than one mole of NaOH would be required (2 moles for  $\text{H}_2\text{SO}_4$  and 3 moles for  $\text{H}_3\text{PO}_4$ ).



Therefore, in such cases, for the calculation of the heat of neutralization, the heat evolved during the neutralization of one mole of the polybasic acid should be divided by the number of water molecules formed i.e. by 2 in the case of  $\text{H}_2\text{SO}_4$  and by 3 in the case of  $\text{H}_3\text{PO}_4$ .

### Precautions

1. For measuring the temperature of water, a thermometer ( $110^{\circ}\text{C}$ ) with graduation of  $0.1^{\circ}\text{C}$  should be used.
2. Pupils should be instructed to read the thermometer accurately and note the temperature after stirring the solution.
3. The temperature of the hot water (in water equivalent experiment) should be taken just before mixing it with the cold water.

## EXPERIMENT NO. 14

*Duration : 14 Periods*

### Objective

Elementary qualitative analysis (determination of one cation and one anion in a given salt).

### Expected learning outcomes

1. Skill of handling laboratory reagents and burner/spirit lamp.
2. Skill of preparing original solution of the salt
3. Skill of analysing anions and cations.
4. Understanding of the ionic reactions involved in the salt analysis.
5. Knowledge of the scheme of salt analysis.
6. Knowledge of the common ion effect in the precipitation of II, III and IV group cations.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Test tubes, boiling tube, test tube stand, test tube brush, test tube holder, glass tube (20 cm length), delivery tube bent twice at right angles, cork, filter papers,  $\text{H}_2\text{S}$  gas apparatus and centrifuge machine.

**Chemicals**

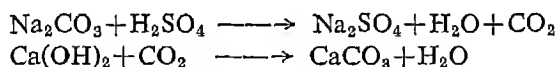
Salt, general and common shelf reagents and commercial sulphuric acid and iron sulphide pellets

**Procedure****TEST FOR ANIONS****STEP—I**

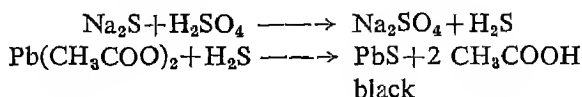
Take a pinch of a salt in a test tube and add 2-3 ml of dil.  $\text{H}_2\text{SO}_4$  and heat.

*(i) Test for carbonate ion ( $\text{CO}_3^{2-}$ )*

If there is effervescence without odour, this indicates the presence of carbonate ion. Add more salt in the same test tube and heat gently and pass the gas evolved in the freshly prepared lime water. If it turns milky, it will confirm the presence of carbonate ion.

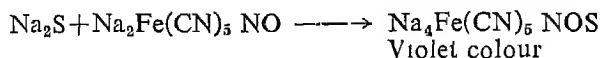
*(ii) Test for sulphide ion ( $\text{S}^{2-}$ )*

(a) If in the case (i) effervescence is not obtained, smell at the mouth of the test tube. A smell of rotten eggs indicates the presence of sulphide ion. Bring a piece of filter paper moistened with lead acetate solution near the mouth of the test tube and heat the test tube. If it turns black, this confirms the presence of sulphide ion.



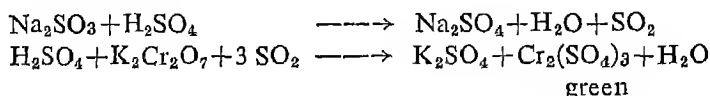
(b) Add  $\text{AgNO}_3$  solution to a test tube containing the salt and dil.  $\text{H}_2\text{SO}_4$ . A black precipitate confirms the presence of  $\text{S}^{2-}$  ion.

(c) Add sodium nitroprusside and sodium hydroxide solutions to the sodium carbonate extract.\* A violet colouration confirms the presence of  $S^{2-}$  ion

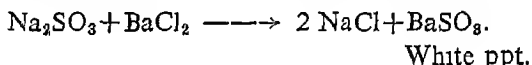


(iii) Test for sulphide ion ( $SO_3^{2-}$ )

(a) If the gas has a suffocating smell of burning sulphur, this indicates the presence of  $SO_3^{2-}$  ion. Put a potassium dichromate paper acidified with dil.  $H_2SO_4$  at the mouth of the test tube. If it turns green, this confirms the presence of  $SO_3^{2-}$  ion.



(b) To the salt solution in water add barium chloride solution appearance of white precipitate soluble in dil. HCl indicates the presence of  $SO_3^{2-}$  ion.

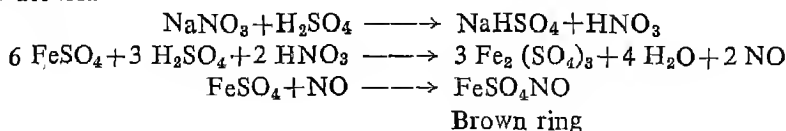


## STEP—II

If no positive result is obtained with dil.  $H_2SO_4$ , take a fresh pinch of salt in a test tube and add to it 2-3 ml of conc.  $H_2SO_4$ . Heat it gently and observe. Brown fumes indicate the presence of bromide or nitrate ions.

*Test for nitrate ion ( $NO_3^-$ )*

(a) Add copper turnings in the same test tube and heat. Excess of brown fumes indicates the presence of  $NO_3^-$  ion. Add ferrous sulphate solution to the salt solution in water without shaking and then add conc  $H_2SO_4$  from the side of the test tube. Brown ring confirms the presence of nitrate ion.




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\*Note : Sodium carbonate extract (S.E) of the salt/mixture may be prepared as follows :

Take 1 gm of the salt/mixture in a porcelain dish or a boiling tube. Mix about 2 gms of solid sodium carbonate and add 10.0 ml of distilled water to it. Stir and boil the contents for 10 minutes. Cool and filter. Collect the filtrate in a test tube. Test the presence of anions with the filtrate



This brown ring is due to the formation of nitroso ferrous sulphate at the junction of the two solutions.

(b) To the salt solution, add diphenylamine solution. Appearance of blue colour confirms the presence of  $\text{NO}_3^-$  ion

#### *Test for bromide ion ( $\text{Br}^-$ )*

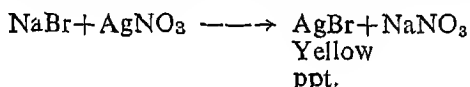
If salt with conc.  $\text{H}_2\text{SO}_4$  gives reddish brown fumes in excess, this indicates the presence of bromide ion.

(a) Add 1 ml of  $\text{CHCl}_3$  or  $\text{CCl}_4$  and chlorine water in excess to the salt solution and shake the test tube vigorously. The presence of red brown colouration in the organic layer confirms the presence of bromide ions.



(Bromine dissolves in the organic solvent and turns the organic layer into deep brown colour.)

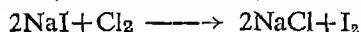
(b) Prepare a sodium carbonate extract of the salt in water and add  $\text{AgNO}_3$  solution to it. Shake the test tube. A pale yellow precipitate slightly soluble in  $\text{NH}_4\text{OH}$  confirms the presence of bromide ions.



#### *Test for iodide ion ( $\text{I}^-$ )*

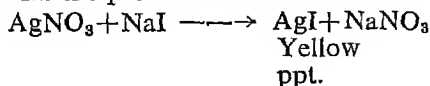
If violet fumes are obtained with salt and conc.  $\text{H}_2\text{SO}_4$ , this indicates the presence of  $\text{I}^-$  ions.

(a) Add 1 ml of  $\text{CHCl}_3$  or  $\text{CCl}_4$  and chlorine water in excess to the salt solution and shake the test tube vigorously. Presence of violet colouration in the organic layer confirms the presence of iodide ions.



(Iodine dissolves in the organic solvent and turns the organic layer into violet colour.)

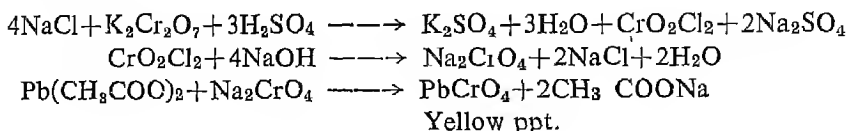
(b) Prepare a sodium carbonate extract of the salt in water and add  $\text{AgNO}_3$  solution to it. Appearance of a yellow precipitate insoluble in  $\text{NH}_4\text{OH}$  confirms the presence of iodide ions.



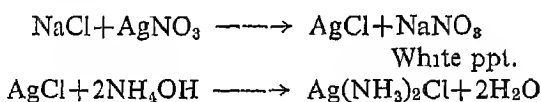
#### *Test for chloride ion ( $\text{Cl}^-$ )*

If a light greenish yellow pungent gas with effervescence is obtained with salt and conc.  $\text{H}_2\text{SO}_4$  in presence of a pinch of  $\text{MnO}_2$ , this indicates the presence of chloride ions.

(a) Take a little amount of salt in a test tube and add to it an equal amount of solid  $K_2Cr_2O_7$ . Add conc.  $H_2SO_4$  to the same test tube and heat it. Pass the gas in NaOH solution. Yellow colouration is obtained. To this solution, add acetic acid and lead acetate. A yellow precipitate is obtained. This confirms the presence of chloride ions (Chromyl chloride test)



(b) Add  $AgNO_3$  solution to the sodium carbonate extract of the salt. Appearance of a white precipitate which is soluble in  $NH_4OH$  solution indicates the presence of chloride ions.

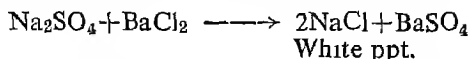


### STEP—III

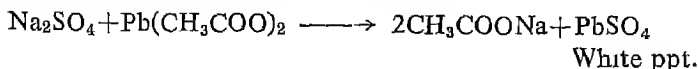
If no positive result is obtained in Step I and II, then test for the presence of sulphate, phosphate and borate ions.

#### *Test for sulphate ion ( $SO_4^{2-}$ )*

(a) Take 1-2 ml of original solution in a test tube and add barium chloride solution to it. A white precipitate insoluble in conc.  $HCl$  and conc.  $HNO_3$  confirms the presence of sulphate ions.



(b) Take 1-2 ml of original solution of sodium carbonate extract in a test tube and add to it lead acetate solution. Appearance of white precipitate confirms the presence of sulphate ion.



#### *Test for phosphate ion ( $PO_4^{3-}$ )*

(a) For testing phosphate ion, take 1-2 ml of original solution in a test tube. Add a few drops of concentrated  $HNO_3$  and boil the solution. Add ammonium molybdate solution in excess. Shake the

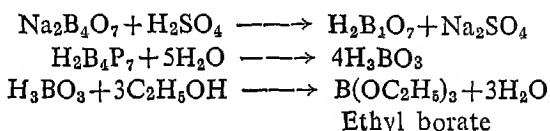
solution. Appearance of yellow colouration or canary yellow precipitate confirms the presence of phosphate ions in the salt. The canary yellow precipitate is of ammonium-Phosphomolybdate  $[(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3]$  is formed.

Note: (If arsenic is present in the second group, take the filtrate of IInd group and test for the presence of phosphate ion).

(b) Prepare a sodium carbonate extract of the salt in water and add cobalt nitrate solution. Appearance of violet precipitate soluble in acetic acid confirms the presence of  $\text{PO}_4^{3-}$  ion.

*Test for borate ion ( $\text{BO}_3^{3-}$ )*

Take a pinch of a salt in a porcelain dish and add to it a small amount of conc.  $\text{H}_2\text{SO}_4$  and a little amount of ethyl alcohol. Stir the mixture and bring a burning splinter near the porcelain dish. A violet compound, ethyl borate is formed which burns with a green flame. The reaction is as follows :



### Remarks

(1) While using concentrated sulphuric acid, pupils should be advised not to throw hot or cold concentrated sulphuric acid into the sink. It should be thrown out in the soil

(2) The pupils should be advised to write only those confirmatory tests which are positively reported

(3) It is advisable to give complete information about the nature of precipitates and the compounds formed during the analysis of anions.

### TEST FOR CATIONS

#### ALTERNATIVE-A

#### STEP I

##### *Preparation of original solution*

Take a little of salt in a clean boiling tube and add a few ml of dil.  $\text{HCl}$ . Heat it for some time till the salt is completely dissolved. If salt

is not soluble in dil HCl, add a few drops of concentrated HCl and heat it again

If the solution is not prepared separate the precipitate and dissolve it in hot water and test for the first group cations.

#### ALTERNATIVE-B

The alternative-A method for the preparation of original solution is most suitable for the pupils of the +2 stage because it will save pupils time during qualitative analysis and avoid confusion. However if teachers feel difficulty, they may use the following traditional method for the preparation of original solution

I Take a little of salt/mixture in a clean boiling tube and add a few ml of water and shake it. If the salt is not dissolved, heat it for some time till it is completely dissolved.

II If the salt/mixture is not soluble in step I, take fresh salt in a clean boiling tube and add a few ml of dil. HCl to it. Heat the boiling tube till the salt/mixture is completely dissolved.

III. If the salt/mixture is not dissolved in the above steps, take fresh salt/mixture in a clean boiling tube and add a few ml of conc. HCl and heat the boiling tube till the salt/mixture is dissolved.

#### STEP II

##### *Group analysis*

(i) Take a small amount of original solution in a test tube and add cold water to it and cool the test tube under tap water. If white precipitate appears, this indicates the presence of  $Pb^{2+}$  ions in group I.

(ii) If group I is absent, add excess of water to the same test tube and then pass  $H_2S$  gas after warming the solution through a clean delivery tube for 1-2 minutes.

Shake the test tube If a precipitate appears this indicates the presence of group II cations.

(iii) If group II cations are absent, take a fresh original solution in a test tube and add to it 2-3 drops of Conc.  $HNO_3$ . Boil the solution for a few minutes. Add a little of solid  $NH_4Cl$  and excess of  $NH_4OH$  solution till the smell of ammonia is obtained. Shake the test tube. If precipitate (Brown or White), is formed, this indicates the presence of group III cations.

(iv) If group III cations are absent, pass  $H_2S$  gas in the above solution for a few minutes If a precipitate appears (white, black or flesh coloured) this indicates the presence of group IV cations.

(v) If group IV cations are absent, take a fresh original solution in a test tube and add to it a little of  $\text{NH}_4\text{Cl}$  (solid) and excess of  $\text{NH}_4\text{OH}$  solution. Then add  $(\text{NH}_4)_2\text{CO}_3$  solution in excess. If a white precipitate appears, this indicates the presence of group V cations.

(vi) If group V cations are absent, take the solution of group V and add disodium hydrogen phosphate solution to it. If a precipitate appears on scratching the walls of the test tube this indicates the presence of group VI cation ( $\text{Mg}^{2+}$ ).

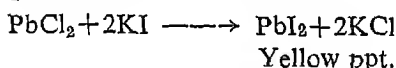
(vii) If group VI is absent, take a pinch of salt in a test tube and add  $\text{NaOH}$  solution to it and heat it. If there is a smell of ammonia, this indicates the presence of ammonium ions, ( $\text{NH}_4^+$ ).

## TESTING OF CATIONS

### GROUP I

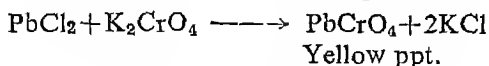
Take the precipitate of group I and dissolve it in hot water. Divide the solution into three parts.

(a) To one part add  $\text{KI}$  solution. Appearance of yellow precipitate confirms the presence of  $\text{Pb}^{2+}$  ions.



This yellow precipitate ( $\text{PbI}_2$ ) is soluble in boiling water and reappears on cooling as shining crystals.

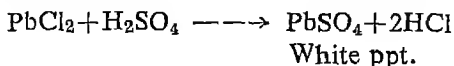
(b) To the second part of the solution, add  $\text{K}_2\text{CrO}_4$  solution. Appearance of yellow precipitate confirms the presence of  $\text{Pb}^{2+}$  ions.



The yellow precipitate ( $\text{PbCrO}_4$ ) is soluble in hot  $\text{NaOH}$  solution.



(c) To the third part of the solution, add a few drops of alcohol and dil.  $\text{H}_2\text{SO}_4$ . A white precipitate of lead sulphate ( $\text{PbSO}_4$ ) confirms the presence of  $\text{Pb}^{2+}$  ions.



### GROUP II

Take the precipitate of group II and add excess of yellow ammonium sulphide solution to it. Shake the test tube. If the precipitate is insoluble,

group II A (copper group) is present. If the precipitate is soluble, this indicates the presence of group IIB (arsenic group).

#### GROUP II A

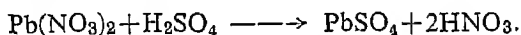
##### STEP I

Take the precipitate in group II in a test tube and wash it with excess of hot water. Dissolve the precipitate in 1 : 2 nitric acid (one part conc.  $\text{HNO}_3$  and 2 parts water) and heat.

##### STEP II

*Test for lead ion ( $\text{Pb}^{2+}$ )*

Take a little of the above solution in a test tube and add dil  $\text{H}_2\text{SO}_4$  and a few drops of alcohol. Shake the test tube. Appearance of a white precipitate indicates the presence of lead ions. The reaction may be given as .



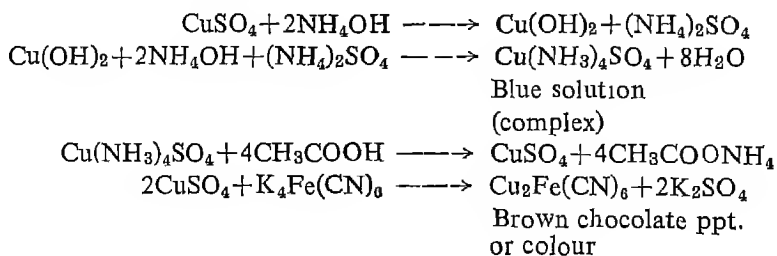
If there is a white precipitate, dissolve it by boiling with ammonium acetate, acidify with acetic acid and add potassium chromate solution. A yellow precipitate of  $\text{PbCrO}_4$  confirms the presence of  $\text{Pb}^{2+}$  ions.

##### STEP III

*Test for copper ion ( $\text{Cu}^{2+}$ )*

(a) If there is no precipitate in step II, take a small amount of solution of step I in a test tube and add excess of  $\text{NH}_4\text{OH}$  to it. Shake the test tube. Appearance of a deep blue colour indicates the presence of  $\text{Cu}^{2+}$  ions.

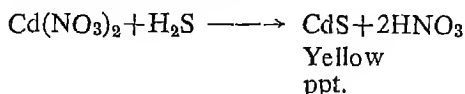
(b) Take a few ml of the above solution in a test tube and add acetic acid till it becomes acidic. The deep blue colour will change into a light blue colour. Now add  $\text{K}_4\text{Fe}(\text{CN})_6$  solution to it. Shake the test tube. A chocolate colouration or precipitate confirms the presence of  $\text{Cu}^{2+}$  ions. The reaction may be given as :



## STEP IV

*Test for cadmium ion ( $\text{Cd}^{2+}$ )*

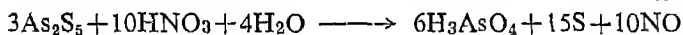
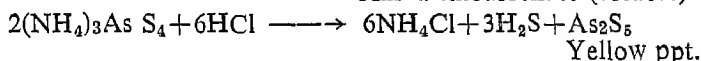
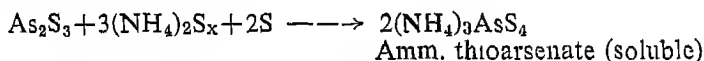
If  $\text{Cu}^{2+}$  ions are absent (no colouration in the presence of excess  $\text{NH}_4\text{OH}$ ),  $\text{Cd}^{2+}$  may be present. Take a few ml of the solution of step I, dilute it with sufficient amount of water, and pass  $\text{H}_2\text{S}$  gas in it. The appearance of a yellow precipitate of cadmium sulphide confirms the presence of  $\text{Cd}^{2+}$  ions in the salt.



## GROUP II B

*Test for arsenic ion ( $\text{As}^{3+}$ )*

If group II precipitate dissolves in yellow ammonium sulphide  $(\text{NH}_4)_2\text{S}$ , this indicates the presence of  $\text{As}^{3+}$  ions. Acidify the solution with dil.  $\text{HCl}$ . A yellow coloured precipitate shows the presence of  $\text{As}^{3+}$ . Dissolve the precipitate in conc.  $\text{HNO}_3$  and add to it ammonium molybdate solution and heat. The appearance of canary yellow precipitate confirms the presence of  $\text{As}^{3+}$  ions.



With ammonium molybdate  $\text{H}_3\text{AsO}_4$  forms  $(\text{NH}_4)_3\text{AsO}_4 \cdot 12\text{MoO}_3$

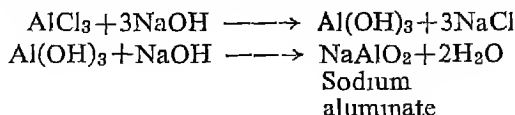
## GROUP III

Take the precipitate of group III and observe its colour and nature. A gelatinous white precipitate indicates the presence of aluminium ion ( $\text{Al}^{3+}$ ). If the precipitate is brown in colour, this indicates the presence of iron ions ( $\text{Fe}^{3+}$ ).

*Test for aluminium ion ( $\text{Al}^{3+}$ )*

Dissolve the precipitate in dil.  $\text{HCl}$  and divide it in two test tubes.

(a) In test tube 1, add sodium hydroxide solution and warm. At first a white gelatinous precipitate appears which dissolves in excess of  $\text{NaOH}$ .

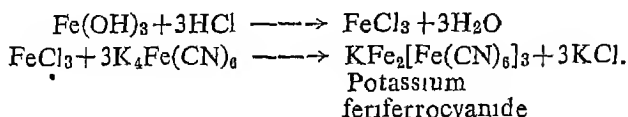


(b) In test tube II add 1-2 drops of litmus (blue) solution A, red colouration is obtained due to the acidic nature of the solution. To this solution add  $\text{NH}_4\text{OH}$  solution drop by drop. A blue precipitate (lake) floating in the liquid confirms the presence of  $\text{Al}^{3+}$  ions.

*Test for iron ion ( $\text{Fe}^{3+}$ )*

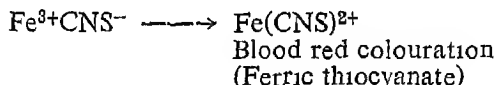
Dissolve the precipitate in dil.  $\text{HCl}$  and divide the solution in two test tubes (I and II)

(a) In test tube I add potassium ferrocyanide solution. The appearance of a prussian blue precipitate/colouration confirms the presence of  $\text{Fe}^{3+}$  ions.



**Note :** Sometimes  $\text{Mn}^{2+}$  ions may also precipitate in the group III (dark brown ppt.) If the presence of  $\text{Fe}^{3+}$  ions is not confirmed, test for  $\text{Mn}^{2+}$  ions as mentioned in group IV.

(b) In test tube II add potassium thiocyanate (potassium sulphocyanide) solution. The appearance of a blood red colouration confirms the presence of  $\text{Fe}^{3+}$  ions



#### GROUP IV

Take the precipitate of group IV and observe its colour. If it is white in colour, this indicates the presence of zinc ions. If the precipitate of a flesh colour, it indicates the presence of manganese ions and if the precipitate is of black colour, it indicates the presence of nickel ions.

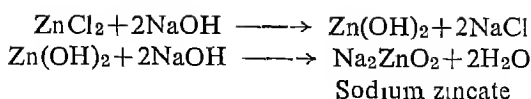
*Test for zinc ion ( $\text{Zn}^{2+}$ )*

(a) Take a little of the precipitate in a test tube and add acetic acid and heat. If it is insoluble, it indicates the presence of  $\text{Zn}^{2+}$  ions.

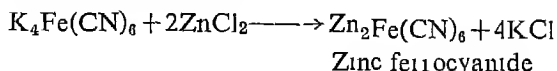
(b) Dissolve the precipitate in dil.  $\text{HCl}$  and boil off the  $\text{H}_2\text{S}$  gas. Divide the solution in two test tubes (I and II).

In test tube I add  $\text{NaOH}$  solution. A white precipitate is formed which is soluble in excess of  $\text{NaOH}$  solution on heating. This confirms the presence of  $\text{Zn}^{2+}$  ions.





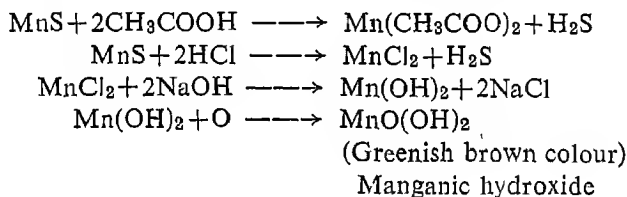
In test tube II add  $\text{NH}_4\text{OH}$  solution till the solution is neutralized and then add to it  $\text{K}_4\text{Fe(CN)}_6$  solution. Appearance of white ppt. of zinc ferrocyanide confirms the presence of  $\text{Zn}^{2+}$  ions.



#### *Test for manganese ion ( $\text{Mn}^{2+}$ )*

(a) Take a little of ppt in a test tube, add acetic acid to it and heat. If it is soluble it indicates the presence of  $\text{Mn}^{2+}$  ions

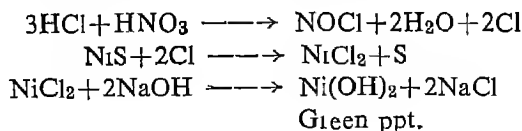
(b) Dissolve the precipitate in dil  $\text{HCl}$  and boil off  $\text{H}_2\text{S}$  gas and then add  $\text{NaOH}$  solution in excess. A white precipitate is formed which turns greenish brown due to its oxidation to Manganic hydroxide.



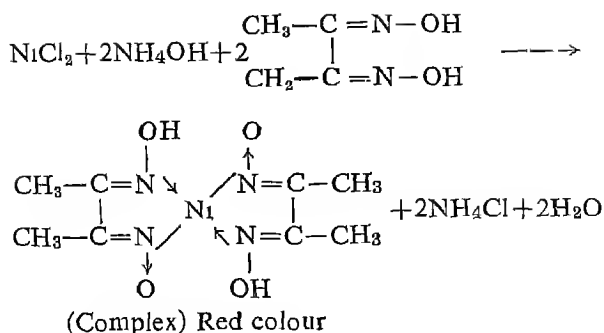
#### *Test for nickel ion ( $\text{Ni}^{2+}$ )*

Dissolve the black precipitate in aquaregia ( $3\text{HCl} + 1\text{HNO}_3$ ) and evaporate it to dryness in a porcelain dish. Dissolve the residue in water

Take a few ml of the above solution in a test tube and add to it  $\text{NaOH}$  solution. A green precipitate confirms the presence of nickel ( $\text{Ni}^{2+}$ ) ions.



To the original solution, add ammonium hydroxide solution in excess and then add Di-methyl glyoxime. Shake the test tube. Appearance of a brilliant red precipitate confirms the presence of  $\text{Ni}^{2+}$ .

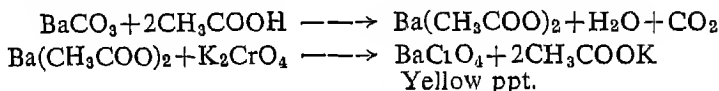


## GROUP V

Dissolve the precipitate in acetic acid and divide into three test tubes (I, II and III)

*Test for barium ion ( $\text{Ba}^{2+}$ )*

To the test tube I add  $\text{K}_2\text{CrO}_4$  solution and shake the test tube. Appearance of yellow precipitate of Barium chromate indicates the presence of  $\text{Ba}^{2+}$  ions. This precipitate is insoluble in acetic acid

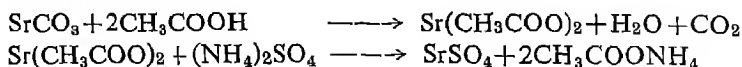


To the original solution add dil  $\text{H}_2\text{SO}_4$ . The formation of a white precipitate insoluble in conc.  $\text{HCl}$  or  $\text{HNO}_3$  confirms the presence of  $\text{Ba}^{2+}$  ions

Take a platinum wire and dip it in conc.  $\text{HCl}$ . Heat it strongly until the wire does not impart any colour to the non luminous flame. Now dip the wire in the precipitate (group V)/salt. Heat it in the flame. A persistent green flame confirms the presence of  $\text{Ba}^{2+}$  ions.

*Test for strontium ion ( $\text{Sr}^{2+}$ )*

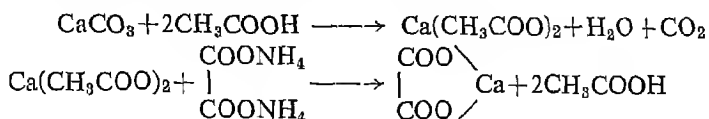
(a) To the test tube II (if  $\text{Ba}^{2+}$  is absent) add  $(\text{NH}_4)_2\text{SO}_4$  solution. Heat and scratch the sides of the test tube with a glass rod and cool. Appearance of white precipitate of strontium sulphate confirms the presence of  $\text{Sr}^{2+}$  ions.



(b) Perform the flame test as mentioned above. A crimson red flame confirms the presence of  $\text{Sr}^{2+}$  ions.

*Test for calcium ion (Ca<sup>2+</sup>)*

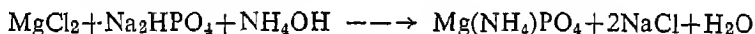
(a) To the test tube III (if Ba<sup>2+</sup> and Sr<sup>2+</sup> are absent) add ammonium oxalate, (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub> solution. Shake the test tube. A white precipitate of calcium oxalate indicates the presence of Ca<sup>2+</sup> ions.



(b) Perform the flame test as mentioned in the case of Ba. A brick red flame confirms the presence of Ca<sup>2+</sup> ions.

## GROUP VI

If there is no precipitate in group Vth, take a few ml of the original solution in a test tube. Add to it solid NH<sub>4</sub>Cl and an excess of NH<sub>4</sub>OH solution. Shake the test tube and then add di-sodium hydrogen phosphate solution. Scratch the walls of the test tube with a glass rod. A white crystalline precipitate of magnesium ammonium phosphate indicates the presence of magnesium (Mg<sup>2+</sup>) ions.

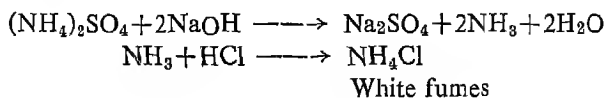
*(b) Cobalt nitrate charcoal cavity test*

Take a pinch of salt in a charcoal cavity. Add to it few drops of Co(NO<sub>3</sub>)<sub>2</sub> solution. Heat it strongly in the reducing flame by a blow pipe. A pink mass is obtained. This confirms the presence of Mg<sup>2+</sup> ions.

*Test for ammonium ion (NH<sub>4</sub><sup>+</sup>)*

(a) Take a pinch of salt in a test tube. Add NaOH solution to it. Heat it and smell the gas. Smell of NH<sub>3</sub> gas indicates the presence of NH<sub>4</sub><sup>+</sup> ions.

(b) Dip a glass rod in conc HCl and bring it at the mouth of the test tube. White fumes of ammonium chloride indicate the presence of NH<sub>4</sub><sup>+</sup> ions.



(c) To the original solution, add Nessler's reagent. A brown colour-  
ation or precipitate confirms the presence of NH<sub>4</sub><sup>+</sup> ions.



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**EXPERIMENTS  
FOR  
CLASS XII**

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## EXPERIMENT NO. 1

*Duration : 2 Periods*

### Objective

Preparation of a double salt of ferrous ammonium sulphate or potash alum.

### Expected learning outcomes

1. Knowledge of calculating molecular mass from the molecular formula.
2. Skill of weighing different salts in appropriate proportions
3. Skill of preparing crystals of a double salt and to test the presence of ions in a double salt.
4. Understanding the theory of double salt formation.
5. Understanding the concept of hydrolysis

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Beaker (250 ml) or conical flask (250 ml), glass rod, tripod stand, funnel, burner, wire gauze and filter papers.

### Chemicals

Ferrous sulphate, ammonium sulphate, potassium sulphate, aluminium sulphate, dil. sulphuric acid and distilled water.

### Procedure

#### *Alternative A*

Molecular mass of ammonium sulphate  $[(\text{NH}_4)_2 \text{SO}_4]$  : 132

Molecular mass of ferrous sulphate  $(\text{FeSO}_4 \cdot 7\text{H}_2\text{O})$  . 278

Weigh 13.0 grams (0.05 mole) of ferrous sulphate and 6.6 grams (0.05 mole) of ammonium sulphate and dissolve them in 20 ml of hot distilled water containing 1-2 ml of dilute sulphuric acid. Stir the solution well and keep it at the room temperature for slow cooling. When the solution is sufficiently cold, separate the crystals by decantation or filtration. Dry the crystals on the two folds of a filter paper. Weigh the dried crystals and note the yield.

#### *Alternative B*

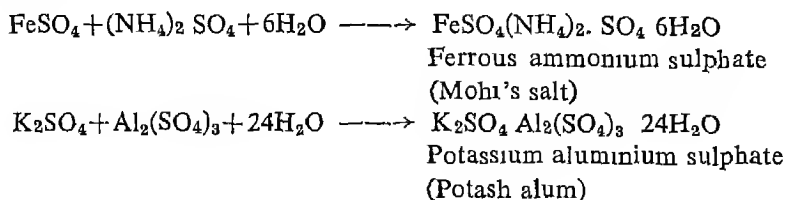
Molecular mass of potassium sulphate ( $K_2SO_4$ ) : 172

Molecular mass of aluminium sulphate  $Al_2(SO_4)_3 \cdot 18H_2O$  : 474

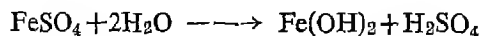
Weigh 33 grams (0.07 mole approximately) of aluminium sulphate and dissolve it in 50 ml of hot ( $70^\circ-80^\circ C$ ) distilled water containing few drops (1-2 ml) of dilute sulphuric acid. Now add 12 grams (0.07 Mole approximately) of potassium sulphate powder to the above solution. Heat the solution with constant stirring till the potassium sulphate is completely dissolved. Keep the solution so prepared at room temperature for slow cooling. When the solution is sufficiently cold, separate the crystals by decantation or filtration. Dry the crystals between the two folds of a filter paper. Weigh the dried crystals and note the yield.

#### **Remarks**

1. When a solution containing equimolar proportions of ferrous sulphate and ammonium sulphate or potassium sulphate and aluminium sulphate is crystallised, a double salt is separated out. The reactions may be given as



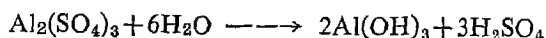
2. Ferrous ammonium sulphate crystals are transparent, octahedral and light green. It is soluble in water and its solution is acidic in nature due to its hydrolysis.



3. The potash alum crystals are colourless, transparent and octahedral



in shape It is soluble in water and its solution is acidic in nature due to its hydrolysis



4. While dissolving aluminium sulphate and ferrous sulphate in warm water a little of sulphuric acid is added in order to prevent the hydrolysis of these salts.

5. Bigger crystals of the double salts can be obtained by slow cooling of the saturated solution of the salts prepared at 40°C and keeping the mixture at room temperature for a longer time (10-12 hours)

### Precautions

1. For the preparation of double salt, pupils should be instructed to mix calculated amounts of salts in calculated quantity of water.

2. Rapid cooling of the mixture of the salt solutions should be avoided.

3. While preparing ferrous ammonium sulphate crystals, heating of the solution should be done for a short time only, because long heating may cause the formation of  $\text{Fe}^{3+}$  ions. This ion would form a ferric alum instead of ferrous ammonium sulphate.

4. During crystallisation, solution should not be disturbed and should be covered with a watch glass

5. Dried crystals should be kept on the cotton or in a dry container.

## EXPERIMENT NO. 2

*Duration : 2 Periods*

### Objective

Study of the interaction of some metals with salt solutions and arranging them according to their activity.

### Expected learning outcomes

1. Knowledge of preparing salt solutions.
2. Skill of observing the interaction of metals with salt solutions.

3. Skill of arranging metals according to their activity.
- 4 Understanding of the electro chemical series
- 5 Understanding of the oxidation and reduction reactions.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Boiling tubes, boiling tube stand and measuring cylinder.

### Chemicals

Magnesium ribbon, zinc, iron, tin, lead and copper strips, molar solutions of zinc sulphate, ferrous sulphate, stannous chloride, lead nitrate, copper nitrate and silver nitrate.

### Procedure

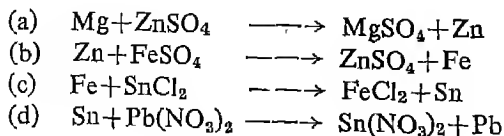
Take six marked boiling tubes (a, b, c, d, e and f) and arrange them in alphabetical order in a boiling tube stand. Pour 30 ml of molar solution of zinc sulphate, ferrous sulphate, stannous chloride, lead nitrate, copper nitrate and silver nitrate in boiling tubes a, b, c, d, e, and f, respectively. Dip metallic strips of nearly equal sizes of Mg, Zn, Fe, Sn, Pb and Cu in boiling tubes a, b, c, d, e and f, respectively.

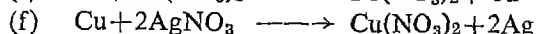
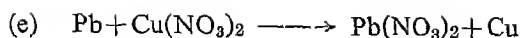
Observe the deposition of metals on the strips after one hour. Leave the apparatus as such for over night and next day again observe these boiling tubes. Record the name of the metals and salt solutions used in a tabular form. Also record the interaction of the metals and the salts.

### Remarks

1 In these experiments, we find that displacement reactions take place. Metal from the strip displaces the metal from the solution of their salts. The reactions which have taken place in boiling tubes a, b, c, d, e and f can be given as follows .

#### *Boiling tube*





In these reactions, metals (Mg, Zn, Fe, Sn, Pb and Cu) are oxidised and the metal ions ( $\text{Zn}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$  and  $\text{Ag}^+$ ) in their corresponding salt solutions are reduced to metals.

2. From the experiment, the metals can be arranged in order of their decreasing activity as follows :

Mg, Zn, Fe, Sn, Pb, Cu, Ag

From this activity series it is observed that Mg can displace Zn, Fe, Sn, Pb, Cu and Ag from their salt solutions. Similarly Zn can displace Fe, Sn, Pb, Cu and Ag. Similarly, Pb can displace Cu but it cannot displace Sn.

If the place of a metal in the activity series is known, it can be predicted whether it will displace other metals from their salt solutions or not. As the activity of metal differ, the more active metal displaces the less active metal from its salt solution.

3. When a metal is dipped in the salt solution of the same metal, no displacement reaction would occur

### Precautions

1. While doing the experiment, pupils should be instructed not to disturb the boiling tubes so that the accumulation of the metal on the metal strips may be compared with each other.

2. The metallic strips should be of nearly uniform size.

3. After finishing the experiment, pupils should be instructed to keep their apparatus at the appropriate places.

## EXPERIMENT NO. 3

*Duration : 2 Periods*

### Objectives

(a) Preparation of colloidal solution of

(i) egg albumin/starch/gum.

(ii) ferric hydroxide/aluminium hydroxide.

(b) Study of the dialysis of starch/egg albumin sol containing sodium chloride through a cellophane/parchment paper (qualitatively)

### Expected learning outcomes

- 1 Knowledge of preparing colloidal solutions.
- 2 Skill of the purification of sol
- 3 Understanding of the phenomenon of dialysis.
- 4 Skill of testing the anions which are present in the colloidal solution.
- 5 Knowledge of solution, colloidal solution and coarse suspension.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Beakers (250 ml), glass rod, watch glass, burner, tripod stand, wire gauze, thread, pipette (10 ml), measuring cylinder, trough and porcelain dish.

### Chemicals

Egg/starch/gum, ferric chloride/aluminium chloride, sodium chloride and distilled water.

### Procedure

#### (i) Preparation of egg albumin/starch/gum sol

(a) *Egg albumin sol* : Prepare a solution of sodium chloride in 100 ml of distilled water. Break one egg in a porcelain dish and such the albumin with a pipette and pour it in sodium chloride solution and stir it well. Compare the sol thus prepared with the egg albumin

(b) *Starch/gum sol* : Take 100 ml of distilled water in a beaker and boil it. Prepare a paste of starch or gum in water and pour a little of this paste in the boiling water with continued stirring. Compare the sol with the paste.

#### (ii) Preparation of ferric hydroxide/aluminium hydroxide sol

Take 100 ml of distilled water in a beaker and boil it. Add 2 grams of ferric chloride/aluminium chloride powder to the boiling water and stir well.

Take 100 ml of distilled water in another beaker and boil it. Pour 10 ml of the above ferric chloride/aluminium chloride solution drop by drop in to the boiling water with constant stirring.

#### *Purification of the sol*

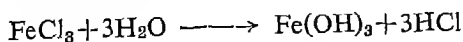
Take a square (30 cm × 30 cm) parchment paper/cellophane. Soak it in water and make it of a conical shape. Pour the colloidal solution (starch/egg albumin sol containing sodium chloride) into it. Tie it with the thread. Suspend the bag in a trough containing distilled water. After a few minutes (30 minutes) test the presence of ions in the trough water. Change the trough water after half an hour and again test the presence of ions in water after half an hour. Change the trough water after every half an hour till it is free from the  $\text{Cl}^-$  ions. (Test the  $\text{Cl}^-$  ions by using  $\text{AgNO}_3$  solution)

*Note:* (i) For the dialysis of starch/egg albumin sol, add 10 ml of 1% solution of sodium chloride in it.

(ii) Dialysis is a slow process. It may sometimes take several days for its completion. Therefore, it is advisable to change the trough water twice or thrice a day till the colloidal solution is free from the ions.

#### **Remarks**

1. White portion of the egg is a condensed colloidal solution whereas the sol prepared from this substance is a dilute colloidal solution
2. The paste of starch/gum is just like a precipitate that settles down if it is kept for sometime whereas a colloidal solution does not settle even after a long time.
3. When ferric chloride/aluminium chloride solution is dropped in boiling water, hydrolysis of the salt takes place and forms hydroxides. This reaction can be given as—



4. In true solution, the solute particles are present as molecules or ions. These molecules and ions mix homogeneously with the solvent molecules and form a single phase. In a colloidal solution, the unit particles are either very large molecules (for example, molecules of starch, gum etc.) or essentially aggregates of a large number of molecules and they remain suspended in the solvent. The size of the colloidal particles is in between the size of the molecules and the size of the particles of a coarse suspension. The colloidal particles cannot be seen by the naked eye but they can be detected by an instrument called ultramicroscope.

5 Sols of ferric chloride and aluminium chloride are positively charged whereas sols of gum and starch are negatively charged. Due to their charges, the colloidal particles remain suspended in the solution and coagulation does not take place.

6 This process is used in urine therapy, preparation of ink and in industries.

### **Precautions**

1. While preparing the colloidal solutions of starch, gum,  $\text{FeCl}_3$ ,  $\text{AlCl}_3$ , etc. paste or solution should be poured gradually into the boiling water with constant stirring. Excess addition of these substances may cause precipitation.

2. During the process of dialysis, pupils should be instructed to make parchment bag airtight and the neck of the parchment cone should be kept above the surface of water otherwise water may enter the parchment cone.

3. Water of the trough should be changed from time to time.

4. After finishing the experiment pupils should be instructed to keep the apparatus at their appropriate places.

## **EXPERIMENT NO. 4**

*Duration . 2 Periods*

### **Objective**

Comparison of the precipitates obtained by adding sodium chloride, barium chloride and aluminium chloride solution to the arsenious sulphide sol.

### **Expected learning outcomes**

1. Knowledge of preparing arsenious sulphide sol and salt solutions.
2. Skill of setting apparatus and comparing the precipitates.
3. Knowledge of the electrical nature of sols.
4. Understanding of the effect of charge of the cation on the precipitation of the sol.

### **Materials required**

(For each pupil or a group of pupils.)

**Apparatus**

Beakers (250 ml), three boiling tubes, Kipp's apparatus, graduated pipette (20 ml), parchment paper and glass rod.

**Chemicals**

Arsenious oxide, sodium chloride, barium chloride and aluminium chloride.

*Note* Teacher may supply arsenious sulphide sol to the students according to the school situation and feasibility of time.

**Procedure**

Dissolve 0.2 gram of arsenious oxide powder in 100 ml of boiling distilled water. Cool and filter the solution. Pass hydrogen sulphide gas through the above solution until it is saturated with the gas (10-15 minutes). Boil off the excess of  $H_2S$  gas from the sol and filter. Now take three marked boiling tubes (A, B and C) and add 25 ml of  $As_2S_3$  sol in each of these boiling tubes. Pour 1 ml of 1M NaCl, 1M  $BaCl_2$  and 1M  $AlCl_3$  in boiling tubes, A, B and C respectively. Shake the boiling tubes and allow the sols to stand for 30 minutes. Compare the precipitate of the boiling tubes A, B and C. Record your observations.

**Remarks**

1. When hydrogen sulphide ( $H_2S$ ) gas is passed into the arsenious oxide solution arsenious sulphide is formed. The reaction may be written as :

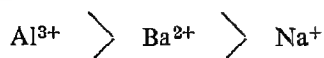


This is a negatively charged sol.

2. When NaCl,  $BaCl_2$  and  $AlCl_3$  solutions are added to the sol, the  $Na^+$ ,  $Ba^{2+}$  and  $Al^{3+}$  ions present in these solutions neutralizes the —ve charge of the sol simply by the absorption of these ions. Thus, the neutral arsenious sulphide particles under the influence of gravity gather together to form bigger aggregates which finally settle down in the form of precipitate.

3. The charge on these ions (i.e.  $Na^+$ ,  $Ba^{2+}$  and  $Al^{3+}$ ) are responsible for the precipitation of the colloidal solution. The coagulating power of the ions depends upon their valency. The higher the valency of the active ion, the greater is its precipitating action. Hence  $Al^{3+}$  ions have more precipitating capacity than the  $Ba^{2+}$  ions and in turn  $Ba^{2+}$  ions have more

precipitating capacity than the  $\text{Na}^+$  ions. The precipitation action of these ions may be represented as .



Hence the precipitate in the boiling tubes A, B and C would be seen to occur in the following order.

ppt in boiling tube C  $>$  ppt. in boiling tube B  $>$  ppt. in boiling tube A.

4 Pupils should be given weighed amount of  $\text{As}_2\text{O}_3$  and prepared molar solutions of  $\text{NaCl}$ ,  $\text{BaCl}_2$  and  $\text{AlCl}_3$  for their practical work.

### Precautions

1. After adding salt solutions (1M  $\text{NaCl}$ , 1M  $\text{BaCl}_2$  and 1M  $\text{AlCl}_3$ ) pupils should be instructed not to disturb the boiling tubes for half an hour so that the precipitates may settle down.

2. After adding  $\text{As}_2\text{O}_3$  in the boiling water, it should be boiled for some time so that  $\text{As}_2\text{O}_3$  may dissolve in water. The undissolved portion should be removed by filtration.

3. Arsenious oxide is very poisonous in nature and hence pupils should be instructed to wash their hands thoroughly after performing the experiment.

## EXPERIMENT NO. 5

*Duration : 2 Periods*

### Objective

Comparison of the effectiveness of a number of oils and emulsifying agents in forming emulsion.

### Expected learning outcomes

1. Knowledge of emulsion formation.
2. Understanding of the effect of emulsifying agent in emulsion formation.



3. Skill of comparing the effectiveness of different oils and emulsifying agents in the formation of emulsion.
4. Application of the principle of emulsification in daily life situations.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Test tubes (six), droppers, glass rod and stop watch/table watch/wrist watch

### Chemicals

Detergent/soap (5 grams), mustard oil (10 ml), linseed oil (10 ml), castor oil (10 ml) and machine oil (10 ml).

### Procedure

Take five marked test tubes A, B, C, D, and E. Prepare the detergent/soap solution in test tube A by dissolving nearly 1 gram of the detergent/soap in 10 ml of water. If necessary, heat the solution. Take 5 ml of water in four test tubes (B, C, D and E) and add 10 drops of mustard oil, linseed oil, castor oil and machine oil in each test tube, respectively. Shake each of these test tubes vigorously for five minutes and record the time taken for the separation of layers in these test tubes separately. Now add two drops of detergent/soap solution in each of these test tubes. Shake these test tubes vigorously for few minutes and record the time for the separation of the layers. Record the observations in a tabular form.

### Remarks

1. When oil is added to water and shaken, a faint milky system is often obtained which is a weak emulsion of oil in water. On standing it is separated into two layers i.e. oil and water. The mixing capacity of different oils with water is different. In some cases they mix very slightly and hence take less time for their separation. In those cases in which oil has a slightly greater capacity to mix with water, more time is required for their separation. The time for the separation of oil and water layers also depends upon the type of shaking i.e. vigorous shaking or swirling. In the first case they take more time whereas in the second case they take less time for their separation.

2. The detergent/soap solution helps in mixing oil and water together. They act as emulsifying agents. An optimum concentration of soap is

required for complete emulsification. Amount less or more than this does not cause effective stabilization. In presence of a soap solution, they will take more time for their separation

3. Soap contains long chain aliphatic compounds with polar groups which decrease the interfacial tension between oil and water. Hence, oil mixes with water or emulsification takes place.

4. Pupils may be advised to see the effect of variation of soap concentration on emulsification.

5. Laboratory reagents such as NaOH and  $\text{Na}_2\text{CO}_3$  may also be used as an emulsifying agent

### Precautions

1. Pupils should be instructed to shake all the test tubes uniformly and equal number of times so that the error in the time required for the separation of layers in different solutions may be minimum.

2. For recording the time pupils should be instructed to start the stop watch when shaking is stopped. Stop the watch when the layers are separated out.

3. Equal number of drops of the soap/detergent solution should be added to all the test tubes.

4. In case stop watch is not available in the school, table watch or wrist watch may be used for this experiment.

## EXPERIMENT NO. 6

*Duration :* 4 Periods

### Objective

(a) Study of the effect of concentration on the rate of reaction between sodium thiosulphate and hydrochloric acid.

(b) Study of the effect of temperature on the rate of reaction between sodium thiosulphate and hydrochloric acid.

### Expected learning outcomes

1. Knowledge of preparing standard solutions
2. Skill of setting apparatus for studying the rate of reaction.

- 3 Skill of titration especially the observation of the end point.
4. Understanding of the effect of concentration and temperature on the rate of reaction.
- 5 Understanding of reaction between sodium thiosulphate and hydrochloric acid.
- 6 Skill of calculating the velocity of the chemical reactions.
7. Skill of plotting the graphs.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Beakers (250 ml), burette (50 ml), pipette (25 ml), burette stand, stop watch, white paper, thermometer ( $110^{\circ}\text{C}$ ), burner, tripod stand and wire gauze

### Chemicals

M/10 sodium thiosulphate solution and 1M hydrochloric acid.

### Procedure

#### (a) *Effect of concentration on the rate of reaction*

Take 50 ml of  $\frac{M}{10}$  sodium thiosulphate solution in a beaker and place it on a piece of paper on which a bold letter 'X' is marked. Add to it 0.5 ml. of 1M hydrochloric acid solution and immediately start the stop watch and swirl the beaker. Place it on the mark X and record the time for the disappearance of the mark X. Similarly, repeat the experiment by adding 1ml, 2ml, 4ml, and 8ml of 1 M hydrochloric acid solution and record the time for the disappearance of the mark X in each case separately. Plot a graph between HCl concentration and time.

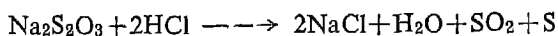
#### (b) *Effect of temperature on the rate of reaction*

Take 50 ml of  $\frac{M}{10}$  sodium thiosulphate solution in a beaker and heat it up to  $30^{\circ}\text{C}$  and then add 5 ml of 1M hydrochloric acid solution. Start the stop watch immediately. Swirl the beaker. Place the beaker on the mark X and note the time for the disappearance of the mark. Similarly repeat the experiment at temperatures  $40^{\circ}\text{C}$ ,  $50^{\circ}\text{C}$ ,  $60^{\circ}\text{C}$ , and  $70^{\circ}\text{C}$  separately and in each case record the time for the disappearance of the mark X. Plot a graph between temperature and time.

**Remark**

1. Velocity of the reaction increases with the increase in the concentration and temperature

2. Sodium thiosulphate reacts with hydrochloric acid and gives the formation of colloidal sulphur which makes the solution opaque. The reaction may be given as follows :



3. For plotting the graphs between concentration against time, and between temperature against time, take concentration and temperature on the Y-axis and time on the X-axis in both the cases.

4. From the graphs of concentration against time and temperature against time, the rate of the reaction at any concentration and the effect of temperature on the rate of reaction can be determined.

5. Exact time for the completion of the reaction (i.e. when mark X becomes opaque) should be noted.

6. If possible use a thermostat (i.e. constant temperature bath) for studying the rate of the reaction. Also while studying the effect of temperature on the rate of reaction, a paper marked X may be pasted at outer surface of the bottom of the beaker and then it may be immersed in the water bath.

7. Ordinary water bath may also be used for maintaining the constant temperature but in this case special care should be taken for the adjustment of the heating source. Water should also be stirred continuously.

**Precautions**

1. Pupils should be instructed to start the stop-watch as soon as half of the hydrochloric acid solution has been transferred to the reaction flask and to stop it when the mark X disappears.

2. While studying the effect of temperature on the reaction rate, pupils should be instructed to heat the sodium thiosulphate solution up to the desired temperature and then add the required amount of HCl to it. Solution should be stirred well and then final temperature should be noted. Also when the solution becomes opaque, the temperature should be noted and an average of these two temperatures should be taken as the temperature of the reaction mixture.

3. Pupils should be instructed to select appropriate scale for plotting the graphs.

**EXPERIMENT NO. 7***Duration : 2 Periods***Objective**

Study of the effect of catalyst on the rate of reaction between oxalic acid and potassium permanganate.

**Expected learning outcomes**

1. Skill of weighing, measuring and mixing reagents.
2. Skill of performing experiment at different concentrations of the catalyst
3. Understanding of the effect of catalyst on the rate of reaction.
4. Understanding of the phenomenon of autocatalysis.
5. Application of the knowledge gained above in studying the rate of other reactions.

**Materials required**

(For each pupil or a group of pupils.)

**Apparatus**

Conical flasks (250 ml-four), burette (50 ml), glazed tile, laboratory stand, stop watch or table watch, and pipette (10 ml).

**Chemicals**

$\frac{M}{50}$  Potassium permanganate solution,  $\frac{M}{10}$  Oxalic acid solution, and manganous sulphate.

**Procedure**

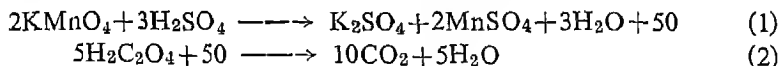
Weigh 0.1, 0.2, 0.4 and 0.8 gram of manganous sulphate powder and keep it in four marked packets A, B, C, and D respectively. Take four conical flasks and mark them a, b, c and d. In flask 'a' take 10 ml of  $\frac{M}{10}$  oxalic acid solution and 10 ml of dil.  $H_2SO_4$  (i.e. one test tube full). Add 5 ml of  $\frac{M}{50}$   $KMnO_4$  solution in it and shake the solution. Record your observations.

In flask 'b', take 10 ml of  $\frac{M}{10}$  oxalic acid solution and 10 ml of dil.  $H_2SO_4$  (one test tube full). Add to it 0.1 gram of manganous sulphate from packet A and shake the solution till it is completely dissolved. Now add 5 ml of  $\frac{M}{10}$   $KMnO_4$  solution from the burette and start the stop-watch immediately. Shake the solution from time to time and note the time required for decolourisation.

Similarly, repeat the experiment by adding different amounts of manganous sulphate from packets B, C and D, respectively. Note in a tabular form the time required for the decolourisation of the  $KMnO_4$  solution. Plot a graph between mass of the manganous sulphate added and time required for the decolourisation of  $KMnO_4$  solution.

### Remarks

1. When  $KMnO_4$  solution is added to the cold oxalic acid solution containing, dil  $H_2SO_4$  the reaction does not take place. At a higher temperature ( $60-70^\circ C$ ),  $KMnO_4$  reacts with oxalic acid with the formation of manganous sulphate which acts as a catalyst. Such a catalyst is called an autocatalyst and this phenomenon is termed as autocatalysis. We find that in the beginning, reaction velocity is slow and then it increases with the formation of the autocatalyst. The reaction may be written as .



In presence of  $H_2SO_4$ , potassium permanganate liberates five oxygen atoms which facilitates the reduction of  $Mn^{7+}$  to  $Mn^{2+}$ , otherwise a black ppt. of  $MnO_2$  will be obtained.

2. When manganous sulphate is added in this reaction mixture, it catalyses the reaction and hence heating is not required.

3. When the concentration of the catalyst (manganous sulphate) is increased, the velocity of the reaction increases as velocity is directly proportional to the concentration of the catalyst added.

4. If a graph is plotted between mass of the manganous sulphate and time required for the completion of the reaction, a straight line is obtained. This also indicates that  $V \propto C$ .

5. The rate of the reaction may also be studied by varying the concentration of the reactants and keeping the amount of the catalyst constant.

### Precautions

1. After adding the powdered  $\text{MnSO}_4$  into the oxalic acid solution, the solution should be shaken well to dissolve it completely
2. Stop watch should be started as soon as the  $\text{KMnO}_4$  solution is added into the conical flask containing oxalic acid, dil.  $\text{H}_2\text{SO}_4$  solution and manganous sulphate.
- 3 Continuous shaking of the reaction mixture is essential

## EXPERIMENT NO. 8

*Duration : 2 Periods*

### Objective

Separation of the following coloured substances by paper chromatography and comparison of their  $R_f$  values.

- (a) Mixture of red and blue ink
- (b) Flower or grass juice

### Expected learning outcomes

1. Skill of preparing solution and extracting juices.
- 2 Skill of paper chromatographic technique.
3. Skill of calculating  $R_f$  values.
- 4 Understanding of the phenomenon of chromatography.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Whatman's filter paper No. 40 of size  $5\text{ cm} \times 17\text{ cm}$ ., gas jars (two-size  $5\text{ cm} \times 20\text{ cm}$ ), rubber corks (two) having hooks in the centre, test tubes and capillary tubes.

### Chemicals

Red ink (2 ml), blue ink (2 ml), flower juice (2 ml) and grass juice (2 ml).

**Procedure****(a) Separation of mixture of red and blue ink**

Take three marked test tubes (A, B and C) containing red ink solution, a mixture of red and blue ink solutions and, blue ink solution respectively. Take a filter paper of size 5 cm × 17 cm. Mark a line at a distance of 3 cm from the one of the ends of the filter paper (i.e. in the direction of length). Put three spots on the line i.e. spot 'a' from red ink solution, spot 'b' from the mixture of the red and blue ink solutions and spot 'C' from the blue ink solution, and allow the spots to dry. Take 50 ml of distilled water in a gas jar. Estimate the position of the hook from the outside of the gas jar so that on dipping the strip in water (solvent), the reference line should be above the surface of the water. Now hang the strip in the estimated position of the hook attached with a rubber cork. Dip the strip in water and fit the cork in the jar. Alternatively, the paper can be fixed by 'agents clip' and can be pressed between two halves of the cork fitted inside the jar. Keep it overnight. Next day remove the filter paper from the jar and dry it. When it is dried, measure the distance of water, red ink, mixture of red and blue inks and blue ink moved from the reference line separately. Calculate the  $R_f$  value for red and blue ink separately by using the expression

$$R_f = \frac{\text{Distance travelled by the substance from the reference line}}{\text{Distance travelled by the solvent from the reference line}}$$

**(b) Separation of flower/grass juice**

Grind flowers/grass in a mortar and transfer the paste into a test tube. Pour 1-2 ml of acetone into this test tube. Close the test tube and shake it well. Filter the solution and collect the filtrate in a test tube and close it. Take a filter paper of size 5 cm × 17 cm and put a spot on the reference line as mentioned above (step a). Hang the filter paper in a jar containing 25 ml of acetone/toluene as mentioned above (step a). Keep this jar as such for an hour so that the solvent rises up. After one hour, remove the filter paper from the jar and dry it. Measure the distance of the solvent moved and of the different spots (obtained on the filter paper) moved from the reference line. Calculate the  $R_f$  value for different spots with the help of the expression as mentioned above (Step a).

**Remarks**

1. Chromatography is helpful in the rapid separation and identification of certain compounds that may require days by other analytical methods.



Chromatographic analysis is possible because various substances in solution are capable of being selectively absorbed on the filter paper.

2. For the extraction of the compounds present in grass and fruits, acetone is the suitable solvent because these compounds are soluble in it.

3. Separation of mixture of two inks is possible as they are differently absorbed on the filter paper.

4. The cations of the group I ( $\text{Ag}^+$ ,  $\text{Pb}^{2+}$  and  $\text{Hg}^{2+}$ ) can be separated by this technique by using equal amounts of acetic acid and water as solvent. Similarly other cations of different groups may be separated by using suitable solvents.

5. For each substance, it is possible to determine a characteristic  $R_f$  (rate of flow) value for any given temperature and given solvent.  $R_f$  value for different substances are different with different solvents. If the substance is coloured its position on the filter paper may be easily identified. When the substance is colourless it is necessary to treat it with a reagent to form a characteristic colour. This reagent is known as developer.

### Precautions

1. While performing the experiment, pupil should be instructed to dip the paper strip in the solvent below the pencil mark.

2. While spotting the test solution on the paper, care should be taken so that the size of the spot does not become big.

3. After setting the experiment, the jar should not be disturbed during the period the solvent is rising.

4. Marking pencil used should be of good quality so that it may not dissolve in the solvent.

5. The paper strip should be dried before measuring the distance of the spots.

## EXPERIMENT NO. 9

*Duration : 4 Periods*

### Objective

Study of some simple reactions of carbohydrates, fats and proteins in pure form and their presence in food stuffs.

### Expected learning outcomes

1. Identification of carbohydrates, fats and proteins in pure form
2. Understanding of the chemical reactions involved in this process.
3. Skill of preparing extract of food materials
4. Skill of detecting the presence of carbohydrates, fats and proteins in food stuffs.
5. Application of the acquired knowledge about food stuffs in selecting eatables for proper nourishment of the human body.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Test tubes, test tube stand, test tube holder and burner

### Chemicals

Glucose, ghee/mustard oil/linseed oil, egg albumin, milk, wheat flour, rice flour, gram flour and commonly used laboratory reagents.

### Procedure

#### STEP I

##### *Identification of carbohydrate*

1. Dissolve 1 gram of glucose in nearly 10 ml of water and divide the solution in three parts (A, B and C). In part A, add 2-3 drops of  $\alpha$ -naphthol solution and 4-5 drops of conc  $H_2SO_4$  from the side of the test tube. A purple colouration develops at the interface of the two layers. This confirms the presence of a carbohydrate.

2. In part B, add Fehling's solution A and B in equal amounts and boil it. The formation of a red precipitate indicates the presence of a carbohydrate.

3. In part C add Benedict's reagent and heat. A red or yellow precipitate of  $Cu_2O$  is formed if carbohydrate is present.

4. Iodine test for starch. To an aqueous suspension of starch in water, a few drops of iodine solution (in water) are added when a blue colour is developed.

#### STEP II

##### *Identification of fats*

1. Dissolve nearly 1 ml of mustard oil/ghee in 5 ml of chloroform and

divide it in two test tubes (A and B). Pour the contents of test tube A in cold water and observe what happens. The oil is separated from the chloroform and forms a separate layer over the surface of water. Add 5-10 drops of iodine solution in test tube B and shake the test tube. The iodine is not dissolved in chloroform layer.

2. Take a few ml of mustard oil/ghee in a test tube and add to it dry potassium bisulphate. Heat the mixture. A pungent smelling compound is formed.

The above two tests confirm the presence of a fat.

### STEP III

#### *Identification of proteins*

1. Take 2-3 ml of egg albumin solution in water and add 2 ml of dil. sodium hydroxide solution to it. Now add a few drops of copper sulphate solution to it and heat the mixture for some time. A violet or pink colour is obtained. The—CONH group present in proteins forms a complex with  $\text{Cu}^{2+}$  ions.

2. Take 2-3 ml of egg albumin solution (in water) in a test tube and add to it 3-4 drops of ninhydrin solution and heat it. A blue colour is produced. The above tests confirm the presence of proteins.

### STEP IV

#### *Identification of carbohydrate, fat and protein in food stuffs*

Mark four test tubes A, B, C and D. In test tube A take 10 ml of milk. In each of the test tubes B, C and D, take 10 ml of distilled water and add 1-2 grams of wheat flour, rice flour and gram flour respectively. Boil the solution, filter and collect the filtrate in three other marked test tubes separately.

Now divide each of the above filtrate into three equal parts and mark them as  $A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3$  and  $D_1, D_2, D_3$ , respectively.

1. In each of the test tubes  $A_1, B_1, C_1$  and  $D_1$  add Fehling's solution (containing of equal amounts of Fehling solution A and B.) Heat the solutions in a boiling water bath and record the observations.

2. In test tubes  $A_2, B_2, C_2$  and  $D_2$ , add nearly 2 ml of sodium hydroxide solution and 5-10 drops of copper sulphate solution. Heat the solution and record the observations in a tabular form.

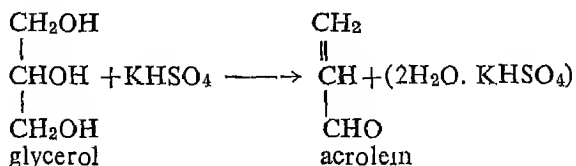
3. In test tubes  $A_3, B_3, C_3$  and  $D_3$  add 1-2 ml of chloroform and then add 4-5 drops of iodine solution. Shake the test tubes and record the observations.

From experiments 1, 2 and 3 it is found that food materials like wheat

flour and gram flour contain carbohydrates and proteins. The rice flour contains carbohydrates and milk contains fats and proteins. Similarly, other food stuffs and fruits may be tested for the presence of organic compounds (carbohydrates, fats and proteins)

### Remarks

1. When fat is heated with potassium bisulphate, the reaction involves hydrolysis of the fat to free glycerol which is then converted into acrolein (Pungent smelling compound). The reaction may be given as :



2. Fehling's solution A is a solution of copper sulphate in water and Fehling's solution B contains potassium hydroxide and potassium sodium tartrate.

3. Benedict's reagent contains sodium citrate, sodium carbonate and copper sulphate.

### Precautions

1. While preparing the extract of the gram, wheat and rice flour pupils should be instructed to shake the contents of the test tube thoroughly.

2. Marking of the test tubes should be done in a systematic order

## EXPERIMENT NO. 10

*Duration : 2 Periods*

### Objectives

- (a) Preparation of standard solutions of oxalic acid and ferrous ammonium sulphate
- (b) Study of the redox titrations of
  - (i) Oxalic acid and potassium permanganate.
  - (ii) Ferrous ammonium sulphate and potassium permanganate.

**Expected learning outcomes**

- 1 Knowledge of calculating molecular mass and preparing molar solutions
- 2 Skill of weighing and titration.
- 3 Understanding of the process of redox titration.
- 4 Skill of making chemical calculations.

**Materials required**

(For each pupil or a group of pupils.)

**Apparatus**

(a) Measuring flask (250 ml), weighing tube, wash bottle, weigh box, chemical balance and physical balance, one pan balance.

(b) Burette (50 ml), pipette (25 ml), conical flask (250 ml), beakers (250 ml-two), burette stand, white glazed tile, burner and wire gauge.

**Chemicals**

(a) Oxalic acid (A.R.) and ferrous ammonium sulphate (A.R.).

(b) Standard oxalic acid solution  $\left(\frac{M}{10}\right)$  standard ferrous ammonium sulphate solution  $\left(\frac{M}{20}\right)$ , potassium permanganate solution and dilute sulphuric acid.

**Procedure**

(i) *Preparation of standard solution of oxalic acid  $\left(\frac{M}{10}\right)$*

Prepare  $\frac{M}{10}$  oxalic acid solution as mentioned in Experiment No. 11 of Class XI

(ii) *Preparation of standard ferrous ammonium sulphate solution  $\left(\frac{M}{20}\right)$*

Molecular mass of  $\text{FeSO}_4(\text{NH}_4)_2 \text{SO}_4 \cdot 6\text{H}_2\text{O} = 392$ .

For  $\frac{M}{20}$  solution weigh approximately 4.9 grams of the substance and transfer it into a measuring flask through a funnel. Wash the funnel with distilled water and then add half test tube of dil.  $\text{H}_2\text{SO}_4$  into the flask. Shake the flask till the substance dissolves and then make up the solution upto the mark. (For further details regarding weighing, transferring the substance, etc. see Experiment No. 11 of Class XI).

(a) *Titration of oxalic acid solution against potassium permanganate solution*

Rinse a clean burette with potassium permanganate solution and then fill the burette with the solution. Remove the air bubble if any from the burette tip by releasing some solution. Take 25 ml of  $\frac{M}{10}$  oxalic acid solution in a conical flask and add one test tube full of dil  $H_2SO_4$  to it. Heat the solution to  $60-70^\circ C$  (unbearable to touch by hand). Now titrate the solution (while hot) against potassium permanganate solution till the colour of the solution changes to pink. Repeat the titration until two concordant readings are obtained. Record the readings and calculate the strength of potassium permanganate solution in mole/litres.

(b) *Titration of ferrous ammonium sulphate solution against potassium permanganate*

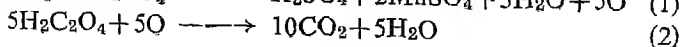
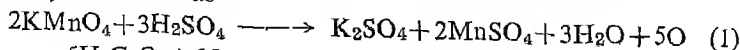
Rinse a clean burette with potassium permanganate solution and then fill the burette with the solution. Remove the air gap, if any, from the burette tip by releasing some solution. Take 25 ml of  $\frac{M}{20}$  ferrous ammonium sulphate solution in a conical flask and add one test tube full (10 ml) of dil.  $H_2SO_4$  in it. Swirl the solution and titrate it against potassium permanganate solution till the colour of the solution changes to pink. Repeat the titration, until two concordant readings are obtained. Record the readings and calculate the strength of potassium permanganate solution in moles/litre

**Remarks**

1. For the preparation of standard solution of oxalic acid see remarks in experiment No. 11, class XI.

2. While preparing the standard solution of ferrous ammonium sulphate a few ml of dil.  $H_2SO_4$  should be added to avoid the hydrolysis of the solution.

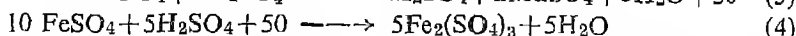
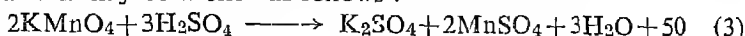
3. During the titration of oxalic acid against potassium permanganate, it is suggested to heat the oxalic acid solution alongwith dil  $H_2SO_4$ . This heating is essential because the reaction takes place at high temperature. During the titration, manganous sulphate is first formed which acts as a catalyst for the reduction of  $KMnO_4$  by oxalic acid. It is found that in the beginning reaction velocity is slow and then it increases. The reaction may be written as :



From the above equations (1 and 2) it is evident that  $\text{KMnO}_4$  is reduced and nascent (atomic) oxygen is produced, which oxidises the oxalic acid into carbon dioxide and water. In this titration, oxidation-reduction (redox) reaction takes place.

4. During titration of ferrous ammonium sulphate against potassium permanganate, reduction of  $\text{KMnO}_4$  takes place in presence of dil.  $\text{H}_2\text{SO}_4$ .

The reaction may be written as follows :



5. Ferrous ammonium sulphate solution should not be heated before titration because it may cause aerial oxidation which would affect the result.

This titration is also known as oxidation reduction titration.

6. For calculating the strength of the unknown solution in terms of molarity the following equation may be used

$$a_1 M_1 V_1 = a_2 M_2 V_2.$$

For oxalic acid—potassium permanganate titration

$a_1 = 2$  (i.e. number of electrons lost per molecule of oxalic acid in a balanced chemical equation).

and  $a_2 = 5$  (i.e. number of electrons gained per molecule of potassium permanganate in a balanced chemical equation).

For ferrous ammonium Sulphate—potassium permanganate titration .

$$a_1 = 1 \text{ and } a_2 = 5.$$

7. In the above titration  $\text{KMnO}_4$  should be added slowly with constant shaking because excess addition of  $\text{KMnO}_4$  may give the formation of a brown precipitate of hydrated manganese oxide.

8. In these titrations, colour of  $\text{KMnO}_4$  solution disappears by the action of reducing agents. As soon as the reduction is complete, even the slightest amount of  $\text{KMnO}_4$  added imparts a permanent pinkish tinge to the solution. This pinkish tinge indicates the end point of the titration.  $\text{KMnO}_4$  acts as an indicator also and it is known as a self-indicator in these titrations.

### Precautions

1. During oxalic acid and  $\text{KMnO}_4$  titration, pupils should be instructed to heat the titration flask (oxalic acid solution + dil.  $\text{H}_2\text{SO}_4$ ) first and then titrate the solution against  $\text{KMnO}_4$ .

2. Pupils should be instructed to add  $\text{KMnO}_4$  solution to the titration flask slowly with constant shaking.

3. While taking burette reading, pupils should be instructed :

- (i) to use autoparallax card,
- (ii) take the readings of the upper meniscus (because in the case of a coloured solution the lower meniscus is not clearly visible).

4. Titration should be repeated until two concordant readings are obtained. Pupils should be instructed not to take average of the readings.

5. Pupils should be instructed to calculate the strength of the unknown solution up to fourth places of the decimal.

6. For other general precautions see Experiment No 12 of Class XI.

## EXPERIMENT NO. 11

*Duration : 12 Periods*

### Objective

Determination of two cations and two anions in a given inorganic mixture.

### Expected learning outcomes

1. Skill of handling of laboratory reagents and burner/spirit lamp
2. Skill of preparing the original solution of the mixture.
3. Skill of analysing cations and anions.
4. Understanding of the ionic reactions involved in the mixture analysis.
5. Knowledge of the scheme of mixture analysis.
6. Application in analysing alloys and minerals.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Test tubes (six), boiling tube-(one), test tube stand, funnel, filter paper, wire gauze, porcelain dish, burner/spirit lamp, test tube brush, test tube holder, Kipp's apparatus and glass tube.

### Chemicals

Common laboratory reagents, commercial sulphuric acid and iron sulphide for preparing  $H_2S$  gas.



## PART I

### *Analysis of anions*

#### STEP I

For the identification of anions, treat the mixture first with dil. HCl or dil.  $\text{H}_2\text{SO}_4$  and test the presence of  $\text{CO}_3^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}^{2-}$  according to the procedure as mentioned in salt analysis.

#### STEP II

Now treat the mixture with conc.  $\text{H}_2\text{SO}_4$  and test the presence of  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$  and  $\text{NO}_3^-$  according to the procedure mentioned in salt analysis.

#### STEP III

For testing the presence of  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ , and  $\text{BO}_3^{3-}$  in the given mixture perform their individual tests as mentioned in salt analysis.

## PART II

### *Analysis of cations*

#### *Preparation of original solution*

Prepare original solution of the given mixture as mentioned in Experiment No. 14 of Class XI.

## PART III

#### 1. *Group analysis*

Analyse the groups of the cations present in the mixture according to the procedure given in Experiment No. 14 (part III) of Class XI mentioned in salt analysis.

#### 2. *Test for cations*

Group I : Test the presence of  $\text{Pb}^{2+}$  ions with the precipitate obtained in group I as mentioned on page number 45. Collect the filtrate of the group I for testing other cations present in the mixture.

Group II . Take the filtrate of group I. Dilute a small quantity of this filtrate and pass  $\text{H}_2\text{S}$  through it. If a precipitate is obtained, dilute rest of the filtrate and warm. Then pass  $\text{H}_2\text{S}$  gas for 4-5 minutes till precipitation is complete. Separate the precipitate and collect the filtrate for group III analysis. If there is no precipitate, group II is absent. Proceed directly for group III after boiling off  $\text{H}_2\text{S}$  gas.

The black colour of the precipitate indicates the presence of  $\text{Pb}^{2+}$  ions or  $\text{Cu}^{2+}$  ions. If the precipitate is of yellow colour,  $\text{Cd}^{2+}$  ions or  $\text{As}^{3+}$  ions may be present

Take the precipitate in a test tube and add yellow ammonium sulphide solution (5-10 ml) and heat it. If precipitate does not dissolve,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$  or  $\text{Cd}^{2+}$  ions may be present. If the precipitate dissolves, it indicates the presence of  $\text{As}^{3+}$  ions

#### *Group II A*

Take the precipitate which is insoluble in yellow ammonium sulphide in a test tube and add to it 50%  $\text{HNO}_3$ . Boil it for few minutes till it is dissolved. Divide it into two parts. In part I, add few drops of dil.  $\text{H}_2\text{SO}_4$  and shake it. The appearance of white precipitate indicates the presence of  $\text{Pb}^{2+}$  ions. Confirm its presence as mentioned in salt analysis. Add excess of ammonium hydroxide to part—II till the smell of ammonia is obtained. Appearance of a deep blue colour indicates the presence of  $\text{Cu}^{2+}$  ions. Confirm its presence as mentioned in salt analysis. If blue colour is not obtained, pass  $\text{H}_2\text{S}$  gas in the solution. Formation of a yellow precipitate indicates the presence of  $\text{Cd}^{2+}$  ions.

#### *Group II B*

Take the solution of the precipitate dissolved in yellow ammonium sulphide solution in a test tube and acidify it with dil.  $\text{HCl}$ . Appearance of a yellow precipitate indicates the presence of  $\text{As}^{3+}$  ions. Confirm its presence as mentioned in salt analysis.

#### *Group III*

Take the filtrate of group II and boil off  $\text{H}_2\text{S}$  gas. Then add few drops of conc.  $\text{HNO}_3$  (to oxidise  $\text{Fe}^{2+}$  ions into  $\text{Fe}^{3+}$  ions) and boil the solution for a few minutes. Then add about 2 grams of solid  $\text{NH}_4\text{Cl}$  to it. Shake the test tube. Now add excess of ammonium hydroxide solution till there is a distinct smell of ammonia. Warm the solution. The appearance of a gelatinous white or brown precipitate shows the presence of  $\text{Al}^{3+}$  or  $\text{Fe}^{3+}$  ions respectively.

Filter the precipitate and collect the filtrate for group IV analysis. Test the presence of  $Al^{3+}$  or  $Fe^{3+}$  ions in the precipitate as mentioned in salt analysis.

Note : Sometimes  $Mn^{2+}$  ions are also precipitated in group III (dark brown ppt) If the presence of  $Fe^{3+}$  is not confirmed, test for  $Mn^{2+}$  ions as mentioned in group IV).

#### *Group IV*

Pass  $H_2S$  gas through a small portion of filtrate of group III. If a precipitate is obtained then pass  $H_2S$  gas in the rest of the filtrate for 2-3 minutes till precipitation is complete. Filter the precipitate and collect the filtrate.

(Note : If group III is absent, pass  $H_2S$  gas in the solution containing  $NH_4Cl$  and  $NH_4OH$ )

The black colour of the precipitate indicates the presence of  $Ni^{2+}$  ions. Confirm it according to the procedure mentioned in salt analysis.

The white or buff coloured precipitate shows the presence of  $Zn^{2+}$  or  $Mn^{2+}$ . Take the precipitate in a test tube and add a few ml of dil.  $HCl$ . Shake and warm till the precipitate is dissolved. Boil the solution to remove  $H_2S$  gas. Cool, add dil.  $NaOH$  solution in excess and shake. If the precipitate dissolves, it shows the presence of  $Zn^{2+}$ . If it is not dissolved,  $Mn^{2+}$  is present. Confirm the presence of  $Zn^{2+}$  or  $Mn^{2+}$  as mentioned in salt analysis.

#### *Group V*

Boil off  $H_2S$  gas from the filtrate of group IV. Concentrate the solution by boiling. Add 2-3 ml of ammonium hydroxide solution and ammonium carbonate solution in slight excess. Shake and keep the solution for about five minutes and filter the precipitate.

If white precipitate is obtained,  $Ba^{2+}$ ,  $Sr^{2+}$  or  $Ca^{2+}$  may be present. Dissolve the precipitate in dil acetic acid solution. Divide it into three parts.

#### STEP I

To the first part add potassium chromate solution. Yellow precipitate of barium chromate confirms the presence of  $Ba^{2+}$  ions. (If there is no precipitate then proceed for Step II.).

**STEP II**

To the second part, add ammonium sulphate solution. Heat and scratch the sides of the test tube with a glass rod. If white precipitate of strontium sulphate is obtained,  $\text{Sr}^{2+}$  ions is confirmed.

**STEP III**

If no precipitate is obtained in step II, then add ammonium oxalate solution in part III. The appearance of white precipitate of calcium oxalate shows the presence of  $\text{Ca}^{2+}$  ions. Confirm the presence of  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$  or  $\text{Ca}^{2+}$  ions with flame test as mentioned in salt analysis.

*Group VI*

To the filtrate of group V add few ml of sodium hydrogen phosphate solution. Scratch the sides of the test tube with a glass rod. The appearance of white precipitate confirms the presence of  $\text{Mg}^{2+}$ .

**Note** If  $\text{Ca}^{2+}$  ions are present in group V then to the filtrate of group V add ammonium oxalate solution and filter and proceed with the filtrate for the analysis of group VI)

*Test of  $\text{NH}_4^+$* 

Take a little amount of mixture in a dry test tube and test the presence of  $\text{NH}_4^+$  ions as mentioned in salt analysis.

**Remarks**

1. For the identification of cations, a systematic group analysis is done.
2. For the analysis of group II the filtrate of group I is taken, similarly for group III analysis, the filtrate of group II is used, and so on.
3. In case group II is absent, original solution may be used for the analysis of group III.
4. Sometimes, the yellowish white precipitate of colloidal sulphur is obtained in group II on passing  $\text{H}_2\text{S}$  gas in the solution. This precipitate is not soluble in hot conc.  $\text{HNO}_3$ . The precipitate of sulphur should be rejected
5. As we reach group V, the filtrate becomes very dilute and the precipitate of group V is not easily obtained. So it is necessary to concentrate the solution before reaching group V.

6 It is always advisable to test  $\text{NH}_4^+$  ions in the beginning.

7 Students are expected to report iron only as  $\text{Fe}^{3+}$ , whether they are given the ferrous or ferric salt since iron is always tested only as  $\text{Fe}^{3+}$  after its oxidation to ferric salt.

## EXPERIMENT NO. 12

*Duration : 4 Periods*

### Objective

Detection of nitrogen, sulphur and Halogens in an organic compound.

### Expected learning outcomes

1. Skill of cutting and handling of metallic sodium.
2. Skill of fusion and preparing sodium extract of the organic compound.
3. Knowledge of the detection of elements such as nitrogen, sulphur and halogens.
4. Understanding of reactions involved in the detection of elements.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Beaker (250 ml), porcelain dish, test tubes, boiling tube, test tube stand, ignition tubes, test tube holder, pair of tongs, funnel, filter paper, tripod stand and wire gauze.

### Chemicals

Sodium metal, carbon tetrachloride/chloroform, distilled water, common and general shelf reagents.

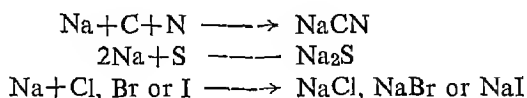
### Procedures

#### I. *Preparation of sodium extract or lassaigue's filtrate*

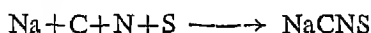
Take a small amount of organic compound in a ignition tube and add a small dry piece of sodium in it. Again add a small amount of organic

compound into the ignition tube, so that the sodium metal is completely covered with the organic compound. First of all heat, the ignition tube gently, till the sodium melts and then heat it strongly to red hot. Drop the red hot ignition tube into a porcelain dish containing 25 ml of distilled water and break the tube into it. Boil the water for sometime and then filter the solution. The filtrate so obtained is known as sodium extract.

During fusion sodium compounds of N, S and halogens are formed as given below :

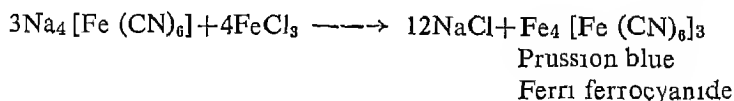
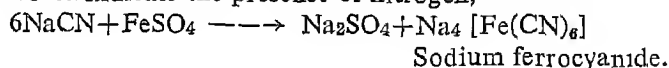


When N and S both are present in the compound, sodium thiocyanate (Sodium sulphocyanide) is formed.



## II. Detection of nitrogen

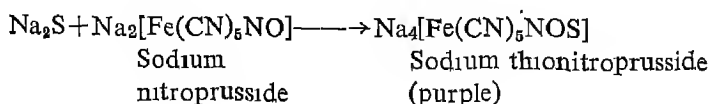
Take 2-3 ml of sodium extract in a test tube and add few drops of NaOH solution into it. Shake the test tube and then add freshly prepared ferrous sulphate solution and boil. Acidify the mixture with hydrochloric acid and then add few drops of  $\text{FeCl}_3$  solution. A blue or green precipitate or colouration would indicate the presence of nitrogen,



### III. Detection of sulphur

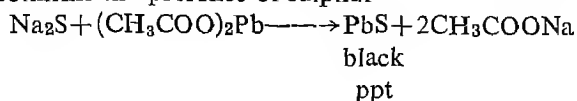
### STEP I

Take 2-3 ml of sodium extract in a test tube and add few drops of fresh sodium nitroprusside solution into it. Shake the solution. Appearance of purple colour would indicate the presence of sulphur.



## STEP II

Take 2-3 ml of sodium extract in a test tube and acidify it with the acetic acid. Now add lead acetate solution to it. Appearance of black precipitate confirms the presence of sulphur

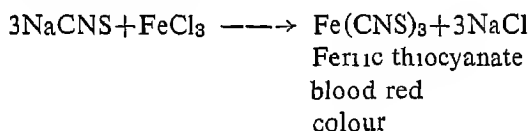


## STEP III

*(Test for nitrogen and sulphur together)*

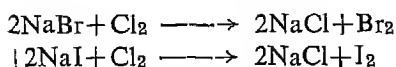
When nitrogen and sulphur both are present in the organic compound, sodium thiocyanate (NaCNS) is produced during fusion.

Take 2-3 ml of sodium extract in a test tube and acidify the solution with hydrochloric acid and then add ferric chloride solution. Shake the test tube. Appearance of blood red colouration would indicate the presence of nitrogen and sulphur both.

IV. *Detection of halogens*

## STEP I

Take 2-3 ml of sodium extract in a test tube and acidify the solution with hydrochloric acid. Now add a little of carbon tetrachloride and excess of chlorine water. Shake the solution vigorously. Appearance of yellow colour in carbon tetrachloride layer indicates the presence of bromine, purple or violet colour indicates the presence of iodine.



bromine and iodine liberated impart their respective colours to carbon tetrachloride layer.

## STEP II

Take 2-3 ml of the sodium extract in a test tube and add a few drops of conc.  $\text{HNO}_3$  in it. Boil the solution for few minutes. Cool the solution

and then add  $\text{AgNO}_3$  solution. Appearance of white precipitate soluble in ammonia solution confirms the presence of chlorine. Yellow precipitate partially soluble in ammonia solution confirms the presence of bromine. Dark yellow precipitate insoluble in ammonia solution confirms the presence of iodine.

### Precautions

1. During fusion, ignition tube should be dry because sodium reacts with water vigorously.
2. After plunging the hot ignition tube into water it should be broken into small pieces with the glass rod.
3. In case sodium piece is burnt inside the tube or thrown outside the tube, repeat the process of fusion by taking another ignition tube.

## EXPERIMENT NO. 13

*Duration : 4 Periods*

### Objectives

Identification of the following functional groups in aliphatic compounds :

- (a) Unsaturation
- (b) Hydroxyl group
- (c) Aldehydic group
- (d) Carboxylic group
- (e) Amino group.

### Expected learning outcomes

1. Knowledge of the functional groups.
2. Skill of detection of functional groups.
3. Understanding of the chemical reactions involved in the testing.

### Materials required

(For each pupil or a group of pupils.)



**Apparatus**

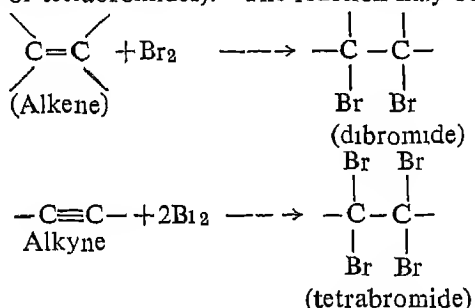
Beakers (250 ml), test tubes, test tube stand, dropper, test tube holder and burner.

**Chemicals**

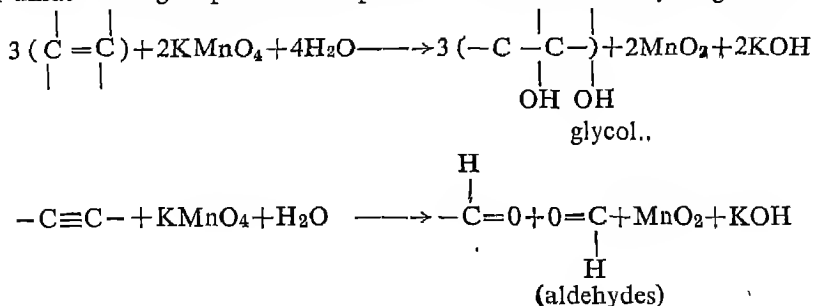
Organic compounds and common laboratory reagents.

**Procedure****1. Test for unsaturation**

(i) Prepare solution of the organic compound in  $\text{CCl}_4$ . Add nearly 1 ml of bromine the solution to it and shake the test tube. The unsaturated compounds react with bromine and form colourless addition compounds (dibromides or tetrabromides). The reaction may be given as :



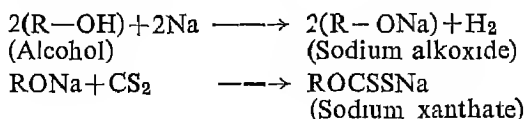
(ii) Take a small amount of the organic compound in a test tube and add 1%  $\text{KMnO}_4$  solution dropwise and after adding each drop shake the test tube. The decolourisation of  $\text{KMnO}_4$  solution indicates the presence of unsaturated group in the compound. The reaction may be given as :



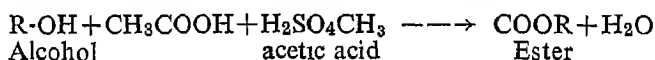
*Note :* If brown vapours (hydrobromic acid) evolve in test (i) presence of a phenol, amine etc., is indicated.

## II. Test for alcoholic group

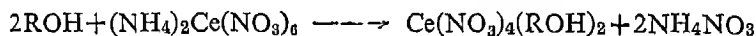
(i) Take nearly 1 ml of the compound in a test tube and add to it a small dry piece of sodium. Reaction takes place vigorously with the evolution of hydrogen gas. Now add a few drops of carbondisulphide in it and shake the test tube. Formation of yellow colour or precipitate indicates the presence of hydroxyl group. The reaction may be given as :



(ii) Take nearly 1 ml of the compound in a clean and dry test tube and add to it nearly 1 ml of acetic acid and a few drops of conc  $\text{H}_2\text{SO}_4$ . Shake and heat the mixture till it boils. Pour this boiled mixture into a beaker containing 25-30 ml of distilled water. A characteristic sweet odour of an ester is obtained. The reaction may be given as :



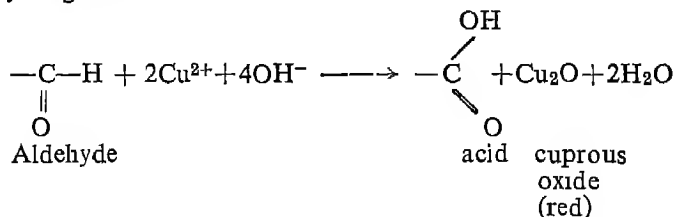
(iii) Take nearly 1 ml of the solution of organic compound in water and add nearly 1 ml of ceric ammonium nitrate solution to it. Shake the solution. The appearance of red colour indicates the presence of hydroxyl group



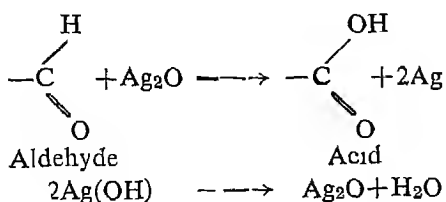
Note : Aromatic amines, phenols and other compounds which get easily oxidised, also produce colour with ceric ammonium nitrate.

## III. Test for aldehydic group

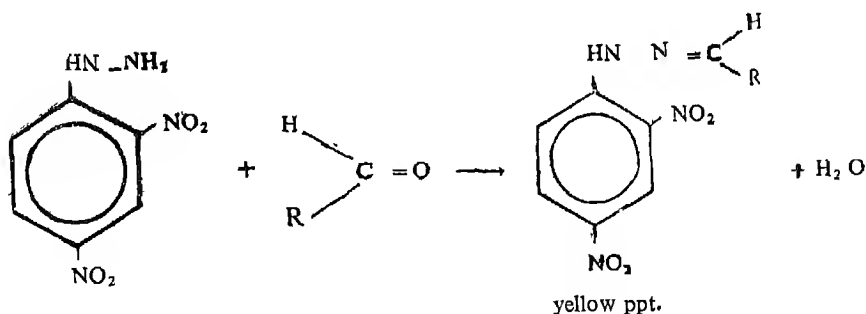
(i) Take 8-10 drops of the organic compound in a test tube and add 1 ml of Fehling's solution (containing equal amounts of Fehling's solution A and B) to it. Shake the solution and boil it. Appearance of Red precipitate ( $\text{Cu}_2\text{O}$ ) indicates the presence of aldehydic group. The reaction may be given as :



(ii) Take nearly 1 ml of silver nitrate solution in a test tube and add 2-3 drops of sodium hydroxide solution to it. Shake the solution. A brownish precipitate is obtained. Now add ammonium hydroxide solution dropwise with constant shaking till the precipitate is dissolved (Tollen's reagent). Now add 4-5 drops of the compound to it. Warm it in hot water and shake the solution. The appearance of silver mirror in the inner side of the test tube indicates the presence of aldehydic group. The reaction is as follows :



(iii) Take 10 drops of the solution of the compound (in alcohol) in a test tube and add nearly 1 ml of saturated solution of 2:4-dinitrophenylhydrazine, in presence of hydrochloric acid. Shake the test tube and keep it for 5-10 minutes. The appearance of yellow precipitate of phenylhydrazone indicates the presence of aldehydic group.

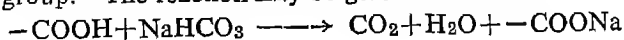


Note . 1. The contents of the test tube after performing Tollern's reagent test should be poured down into the sink and washed off with water.

2. Excess of compound should not be taken as the yellow precipitate may dissolve in the compound.

#### IV. Test for carboxylic group

(i) Take 1-2 ml of saturated solution of sodium bicarbonate in a test tube and add a pinch of the organic compound to it. Shake the contents. Effervescence with evolution of gas ( $\text{CO}_2$ ) indicates the presence of carboxylic group. The reaction may be given as follows :



(ii) Take a few ml of blue litmus solution in a test tube and add a pinch of the organic compound to it. Shake the test tube. The appearance of red colour indicates the presence of carboxylic group

(iii) Take 2-3 ml of ethyl alcohol in a clean test tube and add a pinch of the organic compound to it. Shake the test tube and then add 2-3 drops of conc.  $\text{H}_2\text{SO}_4$  to it. Shake the mixture and warm it. Then pour the contents in a beaker containing 25-30 ml of distilled water. Presence of sweet smell indicates, the presence of carboxylic group due to the formation of ester.

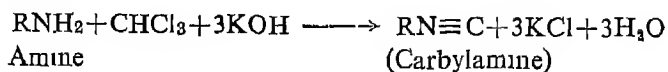
#### V. Test for amino group

(i) Take 2-3 ml of hydrochloric acid in a test tube and add 4-5 drops of the compound to it. Shake the contents. The compound is dissolved in HCl. The reaction is as follows :



Note : Phenolic compounds also give effervescence with sodium bicarbonate.

(ii) Take approximately 1 ml of the compound in a test tube and add approximately 1 ml of chloroform to it. Now add approximately 2 ml of KOH solution (10%) in it. Shake the contents and warm it for some time. Smell the contents. A characteristic unpleasant odour is obtained. This indicates the presence of amino group in the compound. The reaction is as follows .



#### Remarks

1. The unsaturated organic compounds contain either  $(-\text{C}=\text{C}-)$  or  $(-\text{C}\equiv\text{C}-)$  group
2. Aliphatic compounds containing hydroxyl (OH) group are generally in the form of liquids and they are soluble in water.

3. Aldehydes are mostly liquids. Aldehydic  $\left( \begin{array}{c} \text{H} \\ \diagup \\ \text{C} \\ \diagdown \\ \text{O} \end{array} \right)$  group is very reactive and forms mostly addition compounds.

4. Carboxylic acids are mostly found in the form of solids and they are soluble in water. They have a characteristic smell and give acidic test

5. The organic compounds containing amino group are basic in nature. They are mostly in the liquid form. Amines are similar to ammonia in the formation of salts with acids.

6. After performing the carbylamine test the contents should be thrown on the mud/sand as carbylamine is poisonous.



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**INVESTIGATORY  
PROJECTS**

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## INVESTIGATORY PROJECT NO. 1

### Objective

Study of the diffusion of solids in liquid.

### Expected learning outcomes

1. Skill of setting apparatus.
2. Skill of dropping crystals in water.
3. Skill of preparing scale and taking the readings.
4. Understanding the process of diffusion.
5. Application in finding the relationship between the rate of diffusion and molecular mass of the solute.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Gas jars/measuring cylinders (250 ml-three). Three boat shaped glass tubes of the same diameter and same length (30 cm-three), deflagrating spoon (of small diameter with sloopy in design), stop watch/table watch and meter scale.

### Chemicals

Crystals of  $K_2Cr_2O_7$ ,  $CuSO_4 \cdot 5H_2O$ ,  $KMnO_4$ , distilled water and acetic acid.

### Procedure

Take three gas jars or measuring cylinders and fill them with distilled water just below their mouths. Drop equal amounts of crystals of  $CuSO_4 \cdot 5H_2O$ ,  $KMnO_4$  and  $K_2Cr_2O_7$  separately at the bottom of these gas jars

with the help of the deflagrating spoon. Note the rise in the height of the coloured solutions at different intervals of time.

Similarly repeat the experiment with the horizontal boat shaped tubes (Fig. 1.1) and note the length of the coloured solutions horizontally at different intervals of time. Record the readings in the tabular form. Plot graphs between time and height for vertical diffusion and between time and length for horizontal diffusion. From the graphs, calculate the rate of diffusion of solids in water.

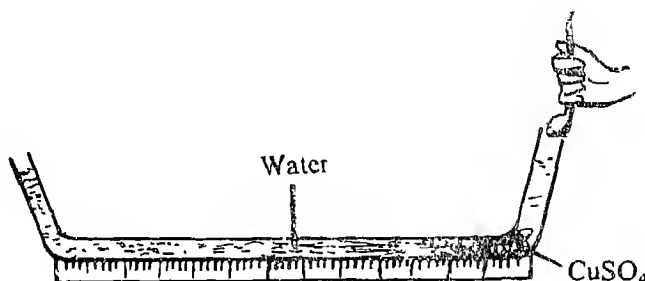


Fig. 1.1

### Remarks

1. When crystals of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ ,  $\text{KMnO}_4$ , etc. are kept in water, diffusion of solute particles in solvent takes place. The rates of diffusion of different substances are different depending upon the characteristics of the solutes.

2. On comparing the rate of diffusion of a particular solute in vertical and horizontal columns, it is found that in the case of vertical diffusion, the rate is slow whereas in the case of horizontal diffusion, rate is fast. This is because during vertical diffusion gravitational force is acting on the solute particles in the reverse direction, whereas, in horizontal diffusion the gravitational force has no such effect.

3. The rate of diffusion of solid in liquid depends upon the temperature, nature of the solute and solvent. The rate of diffusion increases with temperature.

4. The relationship between rate of diffusion and the molecular mass of the solute may be established.

### Precautions

1. While putting the solute crystals in the solvent, pupils should be instructed to keep the solid at the bottom carefully, to avoid the mixing of the solute in the solvent.

2. While plotting the graph between length/height of the coloured solution against time, it is advisable to take time on X-axis and length/height on Y-axis

3. During the experiment, the solution should not be disturbed.

## INVESTIGATORY PROJECT NO. 2

### Objective

Determination of the minimum quantity of manganese dioxide required for the preparation of oxygen gas.

### Expected learning outcomes

1. Skill of setting the apparatus for the preparation of oxygen gas.
2. Skill of collecting the gas and measuring its volume.
3. Understanding the phenomena of catalysis.
4. Knowledge of the chemical reaction taking place during the preparation of  $O_2$  gas.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Hard glass boiling tubes of equal size (six), rubber cork with one hole, delivery tube, trough, beehive shelf, gas jars—each having a paper strip scale, burner/spirit lamp, table watch and laboratory stand with clamps..

### Chemicals

Potassium chlorate and manganese dioxide.

### Procedure

Take five hard glass boiling tubes and mark them as A, B, C, D and E. Take 1.0 gram of potassium chlorate in each boiling tube. Now

weigh 0.1, 0.2, 0.3, 0.4 and 0.5 gram of  $\text{MnO}_2$  separately and add in boiling tube A, B, C, D and E respectively. Mix both the chemicals well in each boiling tube by shaking.

Take the boiling tube A, close its mouth with the rubber cork fitted with a delivery tube. Clamp the boiling tube in the laboratory stand and heat the contents of the boiling tube by a moderate and constant flame. Note the time as soon as the heating is started. Collect the gas by downward displacement of water in gas jars one by one. Note the time again immediately after the bubbles of oxygen ceases to come out. Note the total volume of the gas liberated. Calculate the time required for the completion of the reaction. Repeat the experiment with boiling tubes B, C, D and E. Record the observations in the tabular form.

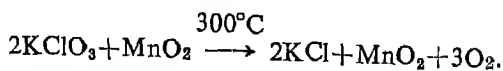
TABLE

Amount of  $\text{KClO}_3$  taken in each tube.

<i>Gas jar No.</i>	<i>Mass of <math>\text{MnO}_2</math> taken in grams</i>	<i>Time required for completion of reaction in minutes</i>	<i>Volume of the gas collected in ml.</i>
A			
B			
C			
D			
E			

### Remarks

When potassium chlorate is heated upto  $800-900^\circ\text{C}$  it liberates oxygen gas. In the presence of manganese dioxide it liberates oxygen gas at lower temperature ( $300^\circ\text{C}$ ). The reaction may be given as :



In this reaction manganese dioxide acts as a catalyst and it increases the rate of the chemical reaction.

2. The amount of oxygen gas liberated depends upon the amount of the potassium chlorate taken for the investigation and it is independent of the amount of manganese dioxide.

3. Only a small quantity of the catalyst is enough to alter the rate of the reaction. When the amount of the catalyst is increased, the rate of the reaction also increases. This is because the rate of the chemical reaction depends upon the surface area of the catalyst.

$$V \propto S$$

where  $v$  is velocity of the chemical reaction and  $s$  is surface area of the catalyst.

4. The catalyst is not used up in the reaction. This can be verified by taking weighed amounts of manganese dioxide with appropriate quantity of potassium chlorate. After the complete decomposition of potassium chlorate in the presence of  $\text{MnO}_2$ , cool the boiling tube upto the room temperature and then add water to it. Potassium chloride formed during the decomposition of potassium chlorate will dissolve in the water leaving  $\text{MnO}_2$  undissolved.  $\text{MnO}_2$  can be separated out by filtration. Dry and weigh it. The mass of  $\text{MnO}_2$  so collected may be compared with the initial mass of  $\text{MnO}_2$  taken for the investigation.

### Precautions

1. Fit the boiling tube in the slanting position with mouth of the tube slanted up.
2. Be careful that when one gas jar is filled with the gas, remove it immediately and place another jar without loss of time i.e. avoiding loss of gas during transferring the gas jar.
3. Remove the delivery tube from the water trough before stopping the heating of the boiling tube, to avoid back suction.

## INVESTIGATORY PROJECT NO. 3

### Objective

Determination of the rate of flow of liquids and solutions horizontally.

### Expected learning outcomes

1. Skill of preparing the improvised apparatus for determining the rate of flow of liquids and solutions.

2. Skill of handling stop watch and taking readings.
3. Skill of calculating the rate of flow in cm/sec
4. Understanding of the dependence of the rate of flow of liquids on their viscosity
5. Understanding of the effect of dissolution of solute in solvent (water).
6. Application in studying the purity of liquids.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Polythene bottle (250 ml), glass tube, rubber cork, pinch cock, wooden meter scale, stop watch and wooden blocks.

### Chemicals

Distilled water,  $\frac{M}{10}$   $\text{KMnO}_4$  solution  $\frac{M}{10}$   $\text{K}_2\text{Cr}_2\text{O}_7$  solution  $\frac{M}{10}$   $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  solution, Benzene, carbon tetrachloride, glycerine and turpentine oil.

### Procedure

Set the apparatus as shown in fig. 3.1. Take a polythene bottle and make a hole of suitable size near the bottom of the bottle. Close the hole with a rubber cork attached with a small glass tube (diameter 0.5 cm).

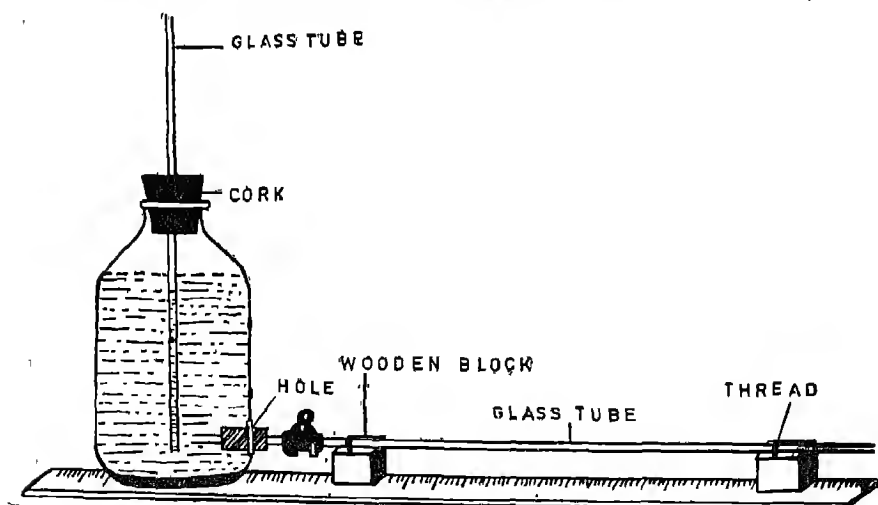


Fig. 3.1

Take a 50 cm long glass tube of diameter 0.5 cm and attach it to the tube fitted in the bottle with the help of a rubber tubing. Now insert a pinch cock on the rubber tubing. Place the bottle on the meter scale. Keep the glass tube horizontal on the meter scale with the help of wooden blocks. Close the mouth of the bottle with a rubber cork fitted with a small glass tube.

Take 200 ml of distilled water in the bottle and close its mouth with the rubber cork. Allow the flow through the glass tube by pressing the pinch cock and note the time required for the flow of water through the glass tube with the help of a stop watch.

Similarly repeat the experiment with solutions of  $\text{KMnO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ ,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  and the other liquids (benzene, carbon tetrachloride, glycerine and turpentine oil, etc.). Calculate the rate of flow of liquid/solution in cms per second. Note the room temperature and record the readings in a tabular form as follows :

TABLE

<i>S. No.</i>	<i>Liquid</i>	<i>Time in seconds</i>	<i>Rate of flow cm/sec.</i>
---------------	---------------	------------------------	-----------------------------

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Compare the rate of flow of different liquids and solutions and draw suitable conclusions.

### Remarks

1. The rate of flow of liquids depends upon various factors such as temperature, viscosity, pressure and the presence or absence of a solute. As the temperature increases, viscosity decreases and hence the rate of flow increases.

2. Different liquids and solutions flow at different rates. The rate of flow of liquids decrease with increase in viscosity i.e.

Rate of flow  $\propto 1/\text{Viscosity}$

3 The compound which has greater number of hydroxyl groups in its molecules has lower rate of flow. It is because of stronger intermolecular forces due to hydrogen bonding. For example, water has one hydroxyl group and glycerine has three hydroxyl groups. It is observed that the rate of flow of water is greater than that of glycerine.

4. The rate of flow of a solution is lesser than that of a pure liquid because the solute molecules do not allow solvent molecules to flow easily. This is due to the stronger forces between the solvent and solute molecules.

### Precautions

1. The level of the tube should be horizontal.
2. There should not be any leakage of water from the hole near the bottom.
3. The amount of the liquid/solution should be the same in each case.
4. After pressing the pinch cock, as soon as the liquid enters the tube, stop watch should be started. It should be stopped as the liquid reaches the other end of the tube.

## INVESTIGATORY PROJECT NO. 4

### Objective

Study of the foaming capacity of different washing soaps and the effect of addition of sodium carbonate to it.

### Expected learning outcomes

1. Skill of preparing soap solution.
2. Skill of weighing, performing experiment and measuring the length of the foam.
3. Understanding of the foaming capacity of the soap solutions and their cleaning effect.



4. Understanding of the effect of adding  $\text{Na}_2\text{CO}_3$  to the soap solution.
5. Application in preparing soaps and selecting the soaps for daily use.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Boiling tubes having paper scale (six), beakers (250 ml-six), physical balance, glass rod and stirrer.

### Chemicals

Six different soaps and detergent samples and sodium carbonate.

### Procedure

Weigh 1 gram of each sample of soap/detergent sample and dissolve it in 100 ml of distilled water. Take 10 ml of the soap solution in a boiling tube and shake the solution with a stirrer making 20 regular strokes so that foam increases uniformly. Measure the length of the foam thus produced with the help of the paper scale. Similarly perform the experiment with other soap solution and measure the length of foam formed in each case.

TABLE

S No.	Name of soap/ detergent	Length of foam produced in the absence of $\text{Na}_2\text{CO}_3$ in cm	Length of foam produced in the pre- sence of $\text{Na}_2\text{CO}_3$ , in cm.

Dissolve 0.5 gram of sodium carbonate in 50 ml of each of the above soap solutions separately. Now take 10 ml of a soap solution in a boiling tube and shake it with a stirrer making 20 regular strokes. Measure the length of the foam so produced. Similarly, perform the experiment with other soap/detergent solutions. Record the observations in a tabular form. Compare the foam produced in different soap/detergent solutions with and without the presence of  $\text{Na}_2\text{CO}_3$ . Draw suitable conclusions.

### Remarks

1. Soaps are sodium or potassium salts of higher fatty acids. The washing property of soaps depends upon the length of long alkyl chain of the fatty acid present in them.

2. Detergents are very much different in chemical nature from ordinary soaps. If unsaturated hydrocarbons of the ethylene type, containing between ten to eighteen carbon atoms are allowed to react with sulphuric acid, some organic acids are formed. The sodium salts of these acids exhibit a remarkable washing property.

3. The washing capacity of soaps depends upon their foaming capacity. The foaming capacity of a soap depends upon the nature of water used, nature of the soap and its concentration.

4. When sodium carbonate is added to the soap solution, its foaming capacity increases, because  $\text{Na}_2\text{CO}_3$  improve the effectiveness of the soap. Such materials are known as 'builders'. Their action is mostly physico-chemical and comprises a series of effects which results in a higher cleaning action of the soap.

### Precautions

1. The soap should be completely dissolved in water.
2. While performing the experiment, strokes should be regular and same in number in all cases.
3. As the foaming capacity depends upon the temperature, the experiment should be carried out at room temperature.

## INVESTIGATORY PROJECT NO. 5

### Objective

Study of the contents of different samples of tea leaves and reasons for the variation in their taste.

### Expected learning outcomes

- 1 Skill of preparing tea extract.
2. Skill of titrating tea extract with NaOH solution
3. Skill of calculating the molar concentration of acid present in different tea extracts
4. Understanding of the contents present in the tea leaves.
- 5 Understanding of the causes for the variation of taste in different samples of tea leaves.
6. Application in selection of tea samples for daily use

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Beakers (250 ml), pipettes (5 ml-five), burette, burette stand, conical flask, filter paper strips, burner/spirit lamp, funnel and wire gauze

### Chemicals

Tea leaves (yellow label, red label, green label and tea dust) 10 grams of each sample,  $\frac{M}{50}$  NaOH solution, Phenolphthalein indicator and common laboratory reagents

### Procedure

#### (a) *Estimation of the acid present in tea leaves*

Weigh 10 grams of each sample of the tea leaves (yellow label, red label, green label and tea dust) separately. And these weighed samples in separate marked beakers each containing 200 ml of distilled water. Heat the contents of each beaker for 10 minutes and then filter the extract so formed.

Take 5 ml of tea extract in a conical flask and add 20 ml of distilled water to it. Shake the solution for homogeneous mixing and then titrate it against  $\frac{M}{50}$  NaOH solution using phenolphthalein as indicator. Similarly, titrate the other tea extracts with  $\frac{M}{50}$  NaOH solution. Record the volume of NaOH used in the tabular form. Calculate the concentration of acid present in the different samples of tea leaves in molarity.

(b) *Effect of acids and bases*

Take five filter paper strips and mark them as A, B, C, D and E. Dip all the strips in a tea extract. Now put two drops of dil. HCl, acetic acid solution, NaOH solution and  $\text{NH}_4\text{OH}$  solution on strips A, B, C and D respectively. Compare the change in colour of these strips with reference to the colour of the strip E.

Similarly, perform the investigation with other tea extracts. Record the observations in the tabular form as follows.

S. No.	Tea leaves extract	Original colour	Effect of different solutions				Conc. of acid present in molarity
			HCl	$\text{CH}_3\text{COOH}$	NaOH	$\text{NH}_4\text{OH}$	
1.							
2.							
3.							
4.							

**Remarks**

1. Tea leaves contain organic compounds (caffeine, tannin, etc.) When tea extract is prepared in water, it gives brownish colour. This colour may be due to the presence of some inorganic ions e.g.  $\text{Mn}^{2+}$ ,  $\text{Fe}^{3+}$ , etc.

2. The amount of caffeine, tannin and polyphenolic compounds varies in different samples. That is why the taste of tea samples differ from one another.

3. The amount of caffeine, present in tea leaves can be determined by treating the tea extract with lead acetate solution which precipitates the glycosidic compounds present in tea leaves in the form of lead complexes.

The filtrate is then treated with small amount of chloroform to extract the caffeine. The chloroform layer containing caffeine can be separated with the help of separating funnel.

From the chloroform extract, chloroform is distilled out leaving the residue in the flask. The residue is dissolved in hot water and caffeine is crystallised.

### **Precautions**

1. The tea leaves should be boiled in water for constant time in each case.
2. Chloroform should not be distilled by heating directly. It should be distilled by heating the flask over water bath.
3. While titrating tea extract with M/50 NaOH solution the dilution of 5 ml of each tea extract should be made by adding equal amount of distilled water (20 ml).

## **INVESTIGATORY PROJECT NO. 6**

### **Objective**

Determination of the rate of evaporation of different liquids.

### **Expected learning outcomes**

1. Skill of weighing.
2. Knowledge of evaporation of different liquids.
3. Skill of calculating the rate of evaporation.
4. Understanding of the causes of evaporation.
5. Application in studying the other properties of the liquids.

### **Materials required**

(For each pupil or a group of pupils.)

### **Apparatus**

Weighing tubes with stoppers (five), weight box, chemical balance and table watch.

### **Chemicals**

Distilled water, ethyl alcohol, benzene, acetone and chloroform.

**Procedure**

Take five clean and dry weighing tubes and mark them as A, B, C, D and E. Weigh each weighing tube with stopper and note their weights. Now pour 10 ml of distilled water, alcohol, benzene, acetone and chloroform in weighing tubes A, B, C, D and E respectively. Weigh again each weighing tube and find the weight of liquid taken in each weighing tube. Record the weights of the liquids in the table.

Remove the stoppers of the weighing tubes and keep them at one place at room temperature. Now after exactly one hour, close the mouth of all weighing tubes with their stoppers and weigh them again one by one. Calculate the loss in the weight in each case and record these differences in weights in the table.

From these readings, determine the rate of evaporation of each liquid in grams per second.

TABLE

<i>S No.</i>	<i>Name of liquid</i>	<i>Weight of liquid before evaporation</i>	<i>Weight of the liquid after one hour</i>	<i>Loss in weight of the liquid</i>	<i>Rate of evaporation in g/sec</i>
1.					
2.					
3.					
4.					
5.					

**Remarks**

1. When liquids are kept in open container, they evaporate, the rate of evaporation is different in different liquids.

2. Molecules in liquid state are in constant motion and possess certain average kinetic energy. Different molecules have different kinetic energies. The molecules which possess high K.E. escape from the surface of the liquid and pass into the vapour state. Due to the evaporation of

molecules from the surface, the temperature of the liquid decreases and hence the average K.E. of the molecules also decreases. Now the molecules which possess K.E. more than the average K.E. evaporate, this process continues till whole of the liquid evaporates.

3. The rate of evaporation depends upon the temperature and the surface area exposed to air. When the temperature increases, the rate of evaporation also increases. When temperature and surface area are kept constant, the liquids which have low boiling points evaporate faster, for example, the boiling points of the liquids under investigation are as follows.

Acetone	— 56°C.
Chloroform	— 61°C
Ethyl alcohol	— 78°C.
Benzene	— 80°C.
Water	— 100°C.

The rate of evaporation will be in the following order :

acetone > Chloroform > Ethyl alcohol > benzene > water.

### Precautions

1. The temperature and the surface area should be the same in each case.
2. Weighing tube should be weighed after closing its mouth with stopper.
3. After one hour all the weighing tubes should be closed.

## INVESTIGATORY PROJECT NO. 7

### Objective

Study of the effect of metal coupling on the rusting of iron.

### Expected learning outcomes

1. Skill of preparing colloidal solution of agar-agar.
2. Skill of setting apparatus.
3. Understanding of the process of rusting and its prevention.

4. Knowledge of the electro-chemical series.
5. Application in selecting iron artical for daily use.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Test tube (five), Rubber corks, test tube stand, glass rod and graduated pipette (5 ml).

### Chemicals

$\frac{M}{10}$  potassium ferricyanide solution, phenolphthalein indicator, distilled water, zinc, magnesium, Copper, Aluminum wire/strips, iron nails (five) of 1.5 cm length and agar-agar.

### Procedure

Take 100 ml of distilled water in a beaker and heat it to boiling. Add one gram of agar-agar powder in the boiling water. Stir the solution well with the glass rod till it is completely mixed in water. Now add 0.5 ml of potassium ferricyanide solution and few drops (5-6 drops) of phenolphthalein indicator in the agar-agar solution while it is hot.

Take five cleaned iron nails. Now wind zinc, magnesium, copper and aluminium wires/strips separately around the four iron nails. Keep them in four marked test tubes A, B, C, and D respectively. Take a cleaned iron nail in test tube marked E. Pour 10 ml of the hot agar-agar solution (prepared as above) in each test tube. Close the mouth of the test tubes with rubber corks. Keep the test tubes in the test tube stand and allow them to stand undisturbed for one day.

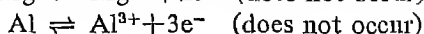
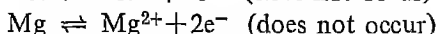
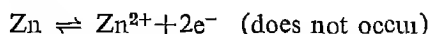
Observe the patches of the colour formed around the iron nail in each test tube. Record the observations in a tabular form.

### Remarks

1. When iron nails are kept in water, rusting takes place. This is due to the formation of iron oxide ( $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ ) on the surface of nails.
2. When iron nails are coupled with metals like Mg, Al and Zn, rusting does not take place because they are more resistant to corrosion than iron. In electrochemical series their position is before iron, i.e., these metals are more electropositive than iron.

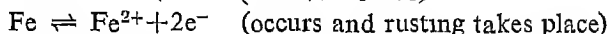
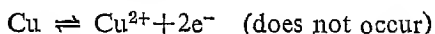


3. In the case of Mg, Zn and Al the patches of different colours are observed. These colours are produced by the metals themselves and the iron remain unaffected. This is due to the absence of  $\text{Fe}^{2+}(\text{aq})$  in the agar-agar solution.



So rusting does not take place.

4. In the case of copper coupling with iron nails, patch of blue colour appears around the iron nails. Here  $\text{Fe}^{2+}(\text{aq})$  are formed which give blue colour of ferri-ferrocyanide. This is because copper is less electropositive than iron hence the rusting process is facilitated.



5. In the case of only iron nail, blue colour of ferri-ferrocyanide appears. This is due to the fact that  $\text{Fe}^{2+}(\text{aq})$  are available and ferri-ferrocyanide complex is formed.



6. As the amount of rust is very small which is difficult to detect with naked eyes, the agar-agar solution is mixed with the solution of 0.1M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  and phenolphthalein indicator.

### Precautions

1. The iron nails should be well cleaned and shining.
2. Agar-agar solution should be poured in the test tubes while it is hot.
3. The test tubes containing iron nails and agar-agar solutions should be kept undisturbed.

## INVESTIGATORY PROJECT NO. 8

### Objective

Study of the effect of acids and bases on the tensile strength of fibres.

### **Expected learning outcomes**

1. Skill of setting apparatus.
2. Skill of determining the tensile strength of the fibres in terms of weights.
3. Understanding of the effect of acids and bases on the tensile strength of the fibres.
4. Knowledge of using appropriate kind of clothes while working in the laboratory.

### **Materials required**

(For each pupil or a group of pupils.)

### **Apparatus**

Weight box, laboratory stand, hanger for keeping the weights, beakers (250 ml), test tubes and table watch.

### **Chemicals**

Fibres of wool, silk, cotton and terylene of same thickness, dil. HCl (1M, 5M and 10M) and dil. NaOH solution (1M, 2M, 5M).

### **Procedure**

#### **STEP I**

Take a cotton thread and cut it out into twenty eight pieces of equal length (20 cm). Now take one piece of the thread and tie its one end with a ring fixed with the laboratory stand and the other with a hanger which carries the weights. Add the different weights (1, 2, 3, 4, 5, 6..... grams) on the hanger and find out the minimum weight required to just break the thread. Note down the reading in the table. Similarly, repeat the experiment by using the threads of wool, silk and terylene of equal length. Record the observations in a tabular form.

#### **STEP II**

Take 100 ml of dil. HCl solution (1M) in a beaker and dip the threads of cotton, terylene, wool and silk of the equal length in it one by one. After five minutes, take out the threads from the beaker and dry them in air. Determine the minimum weight required to just break the thread as mentioned in step I. Record the observations in a tabular form. Similarly

repeat the investigation by taking the different threads and dipping them in the beaker containing dil. HCl (5M and 10M). Also carry out the investigation with dil. NaOH solution (1M, 2M and 5M).

### STEP III

Take 10 ml of dil. HCl solution (1M) in four marked boiling tubes A, B, C and D. Dip one thread of cotton, terylene, wool and silk in boiling tubes A, B, C and D respectively for 15 minutes. Then take them out and dry them in air. Carry out the investigation as mentioned in step I for each thread one by one and note the readings in the table.

Similarly repeat the investigations by dipping the threads in 5M and 10M HCl solution and in NaOH solutions (1M, 2M and 5M).

TABLE

Effect of HCl and NaOH on the tensile strength of various fibres

S. No.	Sample	Weight required to break the fibre in grams	Weight required to break the fibres after dipping in					
			HCl			NaOH		
			1M	5M	10M	1M	2M	5M

### Remarks

1. Various kinds of fibres known today differ in their chemical composition and strength. The strength of a fibre is expressed in terms of its "tensile strength".

2. According to the principle of moments, length (X) × weight (W) = length (Y) × tensile strength ( $S_T$ ).

$$\text{or } S_T = \frac{X \times W}{Y}$$

Keeping X and Y equal, the tensile strength is directly proportional to the weight required to just break the fibre.

It has been observed that alkali decreases the tensile strength of wool and silk, while acid has no effect on them. This happens because animal fibres like wool and silk consist of long polypeptide chains. These fibres gradually dissolve in alkali. On the other hand the acid decreases the tensile strength of cotton and linen while alkali has no effect on them.

This is because cotton and linen fibres are polysaccharides and are made up of carbon, hydrogen and oxygen atoms. Sodium hydroxide solution decreases the tensile strength of the synthetic fibres (Terylene, Nylon etc.) because these fibres gradually dissolve in it. Acid solution has no effect on these fibres.

4. This study provides us the knowledge about the effect of acids and alkalis on the garments which are made up of various kinds of fibres

### **Precautions**

1. Pupils should be instructed to use the threads of equal length and thickness.
2. The tensile strength of the thread should be determined by keeping first the minimum weight and then the weights in the increasing order.
3. Pupils should be instructed to work with aprons on, so as to protect their clothes.

## **INVESTIGATORY PROJECT NO. 9**

### **Objective**

Analysis of the fruit and vegetable juices for the contents present in them.

### **Expected learning outcomes**

1. Skill of extracting fruit and vegetable juices.
2. Skill of performing different tests for the contents present in them.
3. Understanding of the major contents present in these juices.
4. Skill of volumetric analysis.
5. Application in selecting the suitable fruits for their daily use.

### **Materials required**

(For each pupil or a group of pupils.)

### **Apparatus**

Test tubes, conical flasks, burette, pipette and burner/spirit lamp.

**Chemicals**

Fruit and vegetable juices (e.g. lime juice, potato juice, cane sugar juice, apple juice, carrot juice, raddish juice etc ), pH paper, litmus paper and other laboratory reagents.

**Procedure****STEP I**

Take about 50 ml of lime juice, potato juice, cane sugar juice, apple juice, carrot juice, raddish juice in six marked test tubes, A, B, C, D, E and F respectively.

Now determine the acidic/basic nature of these juices by using litmus paper. Record the observations in the tabular form

Determine the pH of the solutions by using pH paper and record the observations in the table.

**STEP II**

Take 5 ml of the filtered lime juice in a conical flask and dilute it with 20 ml of distilled water. Titrate it against the standard  $\frac{M}{100}$  NaOH solution using phenolphthalein as an indicator. Record the observations in this tabular form and calculate the strength in terms of moles per litre. Now repeat the experiment with other juices.

**TABLE I**

<i>S. No.</i>	<i>Name of the juice</i>	<i>Acidic/Basic character</i>	<i>pH</i>	<i>Amount of <math>\frac{M}{100}</math> NaOH used (ml)</i>	<i>Concentration of the acid present in moles/litre</i>
1.					
2.					
3.					
4.					
5.					
6.					

Draw conclusions on the basis of the above observation table.

## STEP III

Take about 2-3 ml of each juice in separate test tube and perform the test for starch as mentioned on page No. 74-75. Similarly perform test for carbohydrate and proteins as mentioned on page No. 74 and 75. Record the observations in the following table and draw conclusions.

TABLE II

S. No	Name of the juice	The Juice Contains		
		Starch	Carbohydrate	Protein
1.				
2.				
3.				
4.				
5.				
6.				

## Remarks

1. Fruit and vegetable juices contain acid. The amount and the kind of acid present in these juices differ from one another.

2. The pH of the juices vary depending upon the concentration of the acids present in them.

3. Fruit and vegetable juices also contains starch, carbohydrate and proteins (amino acids).

4. The concentration of starch, carbohydrate and proteins vary from fruit to fruit or vegetable to vegetable. In some cases sharp test for the presence of the above substances may be obtained whereas in some other cases the test may not be positive.

## Precautions

1. In the case of dark coloured juices, enough dilution should be done in order to get sharp end points during titration.

2. While measuring the pH of the solution, pupils should be instructed to compare the colour of the solution with the colour of the pH chart carefully.

## INVESTIGATORY PROJECT NO. 10

### Objective

Preparation of rayon from filter paper.

### Expected learning outcomes

1. Skill of preparing viscose.
2. Skill of preparing rayon threads.
3. Understanding of the process of rayon formation and chemical reactions involved in it.
4. Knowledge of preparing rayons from other materials containing cellulose.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Conical flasks (250 ml), funnel, glass rod, syringe (10 ml), gravimetric filter papers, glass wool and trough.

### Chemicals

NaOH solution (8M), dil.  $\text{H}_2\text{SO}_4$  and carbon disulphide.

### Procedure

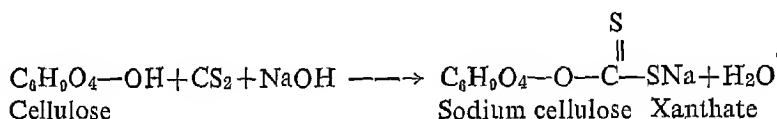
Cut filter paper (3 or 4) into small pieces with the help of scissors. Keep these filter paper pieces in a conical flask containing concentrated solution of NaOH. Boil the contents of the conical flask for at least one hour. Remove the supernatant liquid by decantation process. Add carbon disulphide (100 ml) to the conical flask. Shake well and close the mouth of the flask with a glass stopper. Keep it for one day with shaking at intervals.

A golden yellow coloured viscous solution is obtained. Filter the viscous solution through glass wool and collect the orange coloured syrupy filtrate in the beaker. Concentrate the liquid by keeping it for one day. Now add (2-3 ml) of glycerine. Shake the contents of the flask well.

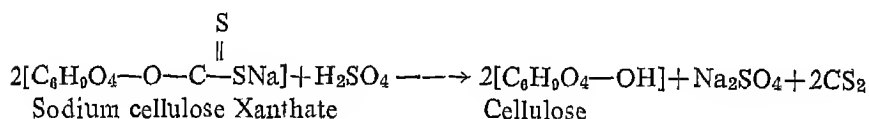
Take the viscous solution in a syringe and force it out through its nozzle into a trough containing dil.  $\text{H}_2\text{SO}_4$  solution. Wash the threads of the rayon so formed with water to remove the excess of acid and then dry by keeping them on ordinary filter paper. Collect the dry threads of the rayon thus formed.

### Remarks

1. When filter paper is dissolved in carbondisulphide in the presence of sodium hydroxide solution, a viscous mass is obtained. This is due to the formation of cellulose xanthate. This is known as "viscose". The reaction may be given as follows :



when cellulose Xanthate (Viscose) is forced out in dil.  $\text{H}_2\text{SO}_4$  through nozzle of a syringe, fine threads, of cellulose are formed. This is due to the regeneration of cellulose from cellulose Xanthate. The reaction is as follows :



2. The dry threads of cellulose thus formed may be twisted into stronger threads.

3. Similarly, rayon can be prepared from other materials containing cellulose such as cotton linters, orange peels etc.

### Precautions

1. The filter papers should be cut into small pieces and they should be thoroughly dipped in  $\text{NaOH}$  solution.

2. The amount of  $\text{CS}_2$  should be sufficient in quantity to dissolve the cellulose of the filter paper.

3. The filtration of viscose should be done through glass wool and not through the filter paper as the filter paper will be dissolved in  $\text{CS}_2$ .

4. The threads of rayons should be dried carefully so that they may not break.



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## **OPTIONAL EXPERIMENTS**

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**OPTIONAL EXPERIMENT NO. 1****Objective**

Study of adsorption of acetic acid on charcoal at two different concentrations.

**Expected learning outcomes**

1. Understanding of the adsorption phenomenon.
2. Knowledge of acid-base titration.
3. Skill of setting apparatus.
4. Skill of calculating the value of  $\frac{x}{m}$ .
5. Understanding about the Freundlich adsorption isotherm.

**Materials required**

(For each pupil or a group of pupils.)

**Apparatus**

Burette, glass bottles, conical flasks (250 ml) with corks, pipette, funnel, filter paper, beaker and measuring cylinder (100 ml)

**Chemicals**

Acetic acid  $\left(\frac{M}{20}\right)$ , sodium hydroxide  $\left(\frac{M}{20}\right)$ , activated charcoal, distilled water and phenolphthalein (indicator).

**Procedure**

Take two conical flasks or glass bottles and mark them A and B. In flask A and B take 50 and 25 ml of acetic acid respectively by using measuring cylinder. In flask B add 25 ml of distilled water to make the volumes of the solution of both the flasks equal. Swirl the solution. Now add 2g of activated charcoal (m) in each conical flask. Cork the flasks and shake them vigorously for half an hour. Keep the flasks for half an hour at room temperature. Filter these solutions separately. While collecting the filtrate reject first few ml of it and then collect the rest of the filtrate in beakers A and B respectively.

Pipette out 10 ml of the filtrate from beaker A. Add 2-3 drops of phenolphthalein indicator to it. Titrate it against  $\frac{M}{20}$  sodium hydroxide solution. Repeat the titration twice or thrice, till you get concordant readings. Similarly, titrate the solution of beaker B by taking 10 ml of it against  $\frac{M}{20}$  NaOH solution to get concordant readings. Calculate the concentration of the acid of both the solutions, (equilibrium concentration  $C_2$ ) in moles per litre and tabulate the results as given below.

Room temperature

Flask No.	Contents		Initial conc( $C_1$ ) in mole/lit. in each flask	Equilibrium conc ( $C_2$ ) in mole/lit. in each flask	Amt. of acid adsorbed in mole/lit. in $x = (c_1 - c_2)$ in each flask	Amt. of acid absorbed per 50 ml $x = (c_1 - c_2) \times 50/100$ in each flask	Mass of charcoal in gram in each flask	$x/m$
	acid ml	water ml						
A.	50.0	0 0						
B	25.0	25.0						

### Remarks

1. When activated charcoal is kept in contact with acetic acid solution, it is observed that the concentration of the acid decreases. This decrease in concentration of the acid is due to the adhesion of the acid molecules on the surface of the charcoal. This phenomenon is known as adsorption. The amount of the acid adsorbed on the charcoal surface depends upon the surface area of adsorbent charcoal and the nature of the adsorbent (charcoal) and the adsorbate (acid solution). The phenomenon was first studied by Freundlich and represented by him in the form of the equation as given below :

$$\frac{x}{m} = KC^{1/n} \quad \dots(1)$$

where  $x/m$  is the amount of the acid adsorbed per unit weight of the charcoal,  $c$ =equilibrium concentration of the acid after adsorption.

k and n are constants, the values of which depend upon the temperature and the nature of the adsorbent and the adsorbate.

2. This experiment may be carried out at different (four or five) concentrations of the acid. A graph between  $\log x/m$  and  $\log C$  can be plotted. From the slope of the graph ( $\tan \theta$ ), the value of  $1/n$  may be calculated. The value of  $\log k$  can be found out by extrapolating the straight line where it cuts the x-axis. At this point ( $\log c=0$ ), the value of  $\log x/m$  is equal to  $\log k$ . This can also be explained by taking the logarithm of equation (1)

$$\log x/m = \frac{1}{n} \log c + \log k. \quad \dots(2)$$

when  $\log c=0$ ,  $\log x/m = \log k$ .

3. The fine particles of the activated charcoal possess residual attractive forces. Because of these forces, the molecules of acetic acid adhere on the surface of the charcoal. The adsorbing capacity of an adsorbent depends upon its porous characteristic and surface area. Larger the surface area, more will be the adsorption. Activated charcoal silica gel, aluminum oxide are good adsorbents.

### Precautions

1. Pupils should be instructed to shake the contents of the conical flasks for half an hour so that a complete adsorption may take place.
2. During filtration first few ml of the filtrate should be rejected in order to minimize the error caused by the adsorption of the acid on filter paper.
3. The amount of charcoal should be weighed accurately and both the reaction flasks should be kept for some time.

## OPTIONAL EXPERIMENT NO. 2

### Objective

Preparation of soaps by using different oils and their comparison with the market soaps by determining the foaming capacity and cleaning effect.

### **Expected learning outcomes**

1. Skill of preparing soaps from different oils.
2. Understanding of the composition of the various constituents present in the soap.
3. Skill of preparing soap solution and determining its foaming capacity.
4. Knowledge of the emulsion formation.
5. Applying the knowledge in comparing the various soap samples available in the market.

### **Materials required**

(For each pupil or a group of pupils.)

### **Apparatus**

Porcelain dish, beakers (250 ml), test tubes of equal size, test tube stand, test tube holder, burner/ spirit lamp, glass rod, and stirrer

### **Chemicals**

Cotton seed (binaula) oil, mustard oil, linseed oil, coconut oil, sodium hydroxide solution (40%), sodium chloride and ethyl alcohol.

### **Procedure**

Take 10 ml of cotton seed oil in a porcelain dish. Heat the oil upto 70°-80°C. Then add 10 ml of 40% sodium hydroxide solution to it with constant stirring. Continue heating for 5-7 minutes untill oily layer is no longer visible. Add 20 ml of distilled water and 5-6 grams of powdered sodium chloride to it with constant stirring. Collect the soap which is separated out in petri dishes and leave it for an overnight for drying.

Similarly, prepare soaps by using other oils, i.e linseed oil, mustard oil and coconut oil. Record the yield of these soaps and note down their colours in a tabular form.

### **Comparison of the foaming capacity of the prepared soaps with the market soaps**

Collect four market soaps of different varieties (soft, hard, glycerine and ordinary washing soap). Also take soap samples prepared as above. Take dry boiling tubes of equal size and beakers of 100 ml capacity. Mark

the boiling tubes and beakers in pairs with the same alphabets a, b, c, d, e,.....

Prepare solutions of the soaps by dissolving 1 gram of each sample in 100 ml of distilled water in separate marked beakers. Take 10 ml of the soap solution from beaker 'a' and pour it into a boiling tube marked 'a'. Shake the solution with the help of a stirrer. Make 20 strokes in such a manner so that the length of the foam increases uniformly. Measure the length of the foam so produced.

Similarly repeat the experiment with other soap solutions and measure the length of the foam produced in each case. Record the results in the tabular form.

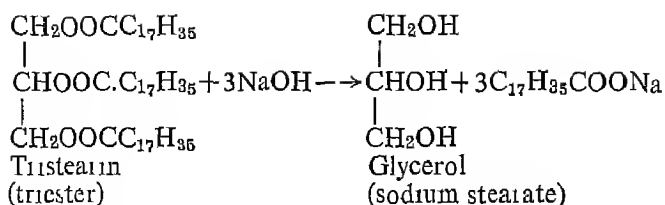
TABLE

Solution No.	Name of the soap	Boiling tube readings		Length of the foam produced in cm.
		Initial length	Final length	
a				
b				
c				
d				
e				
f				
g				
h				

The foaming capacity of different soaps will be in the order of the length of the foam produced.

### Remarks

1. Vegetable oils are the triesters of glycerol and fatty acids, such as palmitic acid ( $C_{16}H_{31}COOH$ ) oleic acid ( $C_{17}H_{33}COOH$ ), stearic acid ( $C_{17}H_{35}COOH$ ). When these triesters are treated with concentrated solution of sodium hydroxide, they form sodium salts of the fatty acids and glycerol. These sodium salts of fatty acids are known as soaps. The reaction may be represented as follows :



This process is known as saponification.

(2) Sodium chloride is used for the separation of soaps from the soap solution. By adding sodium chloride, the concentration of sodium ions is increased in the reaction mixture, thereby the soap is separated out due to common ion (i.e.  $\text{Na}^+$ ) effect.

(3) In order to dry the freshly prepared soap, it should be kept either in an oven at low temperature ( $40-50^\circ\text{C}$ ) for few hours or at room temperature for 24 hours.

(4) The quality of soap depends upon its cleaning capacity. This cleaning capacity depends upon the extent to which the soap can furnish foam with water, that is, on its foaming capacity. The soap which has higher foaming capacity, acts as a better cleaning agent.

(5) The foaming capacity of a soap also depends upon the nature of the water (hard or soft water).

(6) When a piece of cloth is dipped in the soap solution, the solution penetrates into the pores of the cloth. The grease or oil which is present on the surface or in the pores of the cloth forms an emulsion with water in the presence of soap solution. Soap acts as an emulsifying agent. The dirt particles are washed away along with the emulsion with excess of water.

### Precautions

1. During the preparation of soap, the pupils should be instructed to do constant stirring while adding sodium hydroxide solution to the oil, in order to get a homogenous solution.

2. While performing the experiment on foaming capacity, the strokes should be regular so that the length of the foam increases uniformly.

3. Use a scale for measuring the length of the foam in the boiling tube.

Note—It is advisable to prepare scales on paper strips and get them fixed on the boiling tubes.



### OPTIONAL EXPERIMENT NO. 3

#### Objective

Comparative study of the rate of fermentation of the following substances.

- (a) wheat flour
- (b) gram flour
- (c) potato juice
- (d) carrot juice
- (e) orange juice
- (f) apple juice
- (g) cane sugar juice.

#### Expected learning outcomes

1. Skill of setting apparatus, weighing and mixing of the reactants, in appropriate quantities.
2. Understanding of the phenomena of fermentation.
3. Knowledge of recognising the fermented products
4. Knowledge of studying the rate of the chemical reaction.
5. Application of the fermentation process in day to day life.

#### Materials required

(For each pupil or a group of pupils.)

#### Apparatus

Measuring flask (100 ml), balloons, thread and table watch.

#### Chemicals

Yeast powder, wheat flour (100 g ) gram flour (100 g) potato juice (100 ml), carrot juice (100 ml), orange juice (100 ml), cane sugar juice (100 ml) and distilled water.

#### Procedure

Take two measuring flasks labelled A and B each of 100 ml capacity. Add 10 grams of wheat flour and 10 grams of gram flour in flask A and B

respectively. Now add distilled water to the flasks to make up the volume upto the mark. Shake the solutions well. Add 2 grams of yeast powder in each flask and then shake them well. Fit balloons on these flasks and tie them with the threads to avoid leakage of the gas.

Observe the reaction with the inflation of the balloons and record it in the tabular form.

TABLE

*Temperature*

Total volume of the solution = 100 ml

Amount of yeast added = 2 grams.

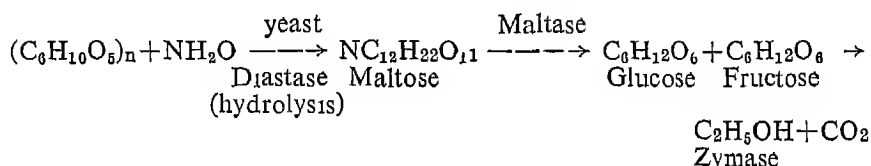
<i>Flask No.</i>	<i>Solution</i>	<i>Time in hours</i>	<i>Inflation in the balloons</i>
A	Wheat flour solution	0	
		4	
		8	
		12	
		20	
		24	
B	Gram flour solution	0	
		4	
		8	
		12	
		20	
		24	

The rate of fermentation of different substances is to be denoted by the rates of the inflation of their corresponding balloons.

Similarly, the experiment may be performed with other substance such as potato juice, carrot juice, orange juice, apple juice and cane sugar juice.

### Remarks

1. When yeast is mixed with the solution of wheat flour or gram flour or any of the above mentioned juices, fermentation takes place. This is due to the living yeast cells which are present in the dry yeast. During this process many kinds of organic acids, alcohols and carbon dioxide gas are produced as by-products. One of the reactions occurring during fermentation process in the presence of enzyme maltase and zymase may be given as :



Similarly, the starch which we eat, is converted in our body into maltose, glucose and fructose and finally to ethyl alcohol and carbon dioxide through the process of fermentation. In this process enzymes present in saliva work as a catalyst.

2. The rate of fermentation increases with the time at optimum temperature. It also depends upon the concentration of substances undergoing fermentation.

3. Enzymes which catalyse the fermentation process, work in a limited temperature range, i.e. usually 30-40°C.

4. The gas collected in the balloons may be tested with lime water to confirm the formation of  $\text{CO}_2$  during the process of fermentation.

### Precautions

1. While performing the experiment, pupils should be instructed to tie balloons on the measuring flasks carefully so that there should not be any leakage of the gases formed.

2. The reaction flasks should not be kept near hot objects such as burner or spirit lamp.

3. The fermentation process with yeast is slow, therefore pupils should be instructed to take reading in hours and reaction mixture should be kept over-night.

4. After adding yeast in the reaction flasks it should be shaken well.
5. After studying the reaction, the flasks should be washed well.

### OPTIONAL EXPERIMENT NO. 4

#### Obejective

Study of the digestion of starch by salivary amylase and effect of pH and temperature on it.

#### Expected learning outcomes

1. Skill of preparing starch solution and collecting saliva.
2. Skill of mixing the reagents and studying the rate of reaction.
3. Understanding of the process of digestion by saliva within the human body.
4. Understanding of the effect of temperature and pH change on the digestion of starch by saliva.
5. Application in studying other enzymic reactions.

#### Materials required

(For each pupil or a group of pupils.)

#### Apparatus

Test tubes, test tube stand, beakers, boiling tube, burner or spirit lamp, thermometer, conical flask (250 ml) and watch glass.

#### Chemicals

Starch powder, saliva, distilled water, sodium chloride, iodine, Benedict's solution or Fehling's solution.

## Procedure

### STEP I

#### *Preparation of starch solution*

Take 100 ml of distilled water in a conical flask and boil it. Take about 1 gram of starch powder in a watch glass and prepare its paste with a few drops of water. Pour this paste into the conical flask containing boiling water. Stir the solution well.

### STEP II

#### *Collection of saliva*

Take about 20-30 ml of warm distilled water (30-40°C) in the mouth and mix it with the saliva by goggling in the mouth. Collect the saliva mixed water in a beaker. This is the saliva solution required for the experiment which contains the enzyme ptyalin.

### STEP III

#### *Digestion of starch by saliva solution*

Arrange eight clean test tubes in a test tube stand and mark them 1, 2, 3,..... Take 5 ml of distilled water in each test tube. Add nearly 4-5 drops of iodine solution in each of the test tube

Take 10 ml of the starch solution in a boiling tube and add 2 ml of 1% sodium chloride solution to it. Keep the boiling tube in water bath, maintained at 38-40°C for at least 15 minutes. Pour 2 ml of the saliva solution in the boiling tube and start stop watch immediately. Take out 2-3 drops of the mixture after 1 minute and pour it in the test tube No. 1. Shake the test tube and note the colour of the solution, if any. Similarly take out 2-3 drops of the mixture from the boiling tube after every one minute and add to the test tubes arranged serial wise. Record the colour of the solution in each case. Stop taking readings when there is no change in colour. Record the readings in a tabular form.

### STEP IV

#### *Effect of temperature and pH on the digestion of starch by saliva*

(a) In order to study the effect of temperature on the digestion (hydrolysis) of starch by saliva, keep the boiling tube containing starch

and sodium chloride in the water bath maintained at 50°C. After 15 minutes add 2 ml of saliva in the boiling tube. Perform the experiment as given above in step III and record the observations after every minute.

(b) Keep the boiling tube containing starch and sodium chloride in the water bath maintained at 38-40°C. Add 3-4 ml of dil. HCl to it. After 15 minutes pour 2 ml of saliva solution in the boiling tube and record the observations after every minute as made in step III.

Similarly, the effect of an alkali can also be studied by adding dil. NaOH solution to the reaction mixture.

### Remarks

1. When saliva is added to starch solution, hydrolysis of starch takes place. During this process, maltose and glucose are formed by the action of ptyalin present in the saliva. Thus, the concentration of starch decreases continuously and hence the intensity of blue colour with iodine solution goes on decreasing with time. After some time when whole of the starch is hydrolysed, blue colour disappears.

2. This reaction is very sensitive to the temperature. When the temperature increases beyond 40°C, the enzymes become inactive and hence the reaction is inhibited.

3. The reaction is carried out in neutral medium (pH=7.0). A slight change in pH, by adding acid or alkali, checks the hydrolysis of starch.

4. This is also a fermentation process in which big organic molecules are converted into many smaller molecules by the action of bio-organic catalysts called enzymes (ptyalin).

### Precautions

1. Temperature of the water bath should be maintained at 38-40°C.
2. The solution of starch, sodium chloride and saliva should be prepared in distilled water.
3. Thoroughly washed test tubes, boiling tubes and conical flasks etc. should be used.

## OPTIONAL EXPERIMENT NO. 5

### Objective

Determination of the effect of impurities on the freezing point/boiling point of the solvent (water).

**Expected learning outcomes**

1. Skill of setting apparatus for determining the freezing point/boiling point.
2. Skill of weighing of substances and reading the thermometer.
3. Skill of calculating the depression in freezing point ( $\Delta T_f$ )/elevation in boiling point ( $\Delta T_b$ ).
4. Understanding of the effect of impurities on the freezing point/boiling point of a solvent.
5. Applying the knowledge in determining the molecular weight of the dissolved substance.

**Materials required**

(For each pupil or a group of pupils )

**Apparatus**

Two boiling tubes (coining), one long test tube, 110°C thermometer of graduation of 0.1°C, stirrer, tin box, rubber corks, conical flasks (150 ml), glass tube, delivery tube, burner or spirit lamp, laboratory stand with clamps, wire gauze, tripod stand and physical balance.

**Chemicals**

Cane sugar, distilled water, common salt and ice.

**Procedure**

(A) *Effect of impurities on the freezing point of water*

Take 5 ml (w<sub>2</sub>g) of distilled water in a long test tube and fit a rubber cork in it and insert a 110°C thermometer and stirrer in it.

Take the rubber cork of boiling tube size having one hole in the middle. Insert the long test tube into the rubber cork. Now fix the long test tube into the boiling tube in such a

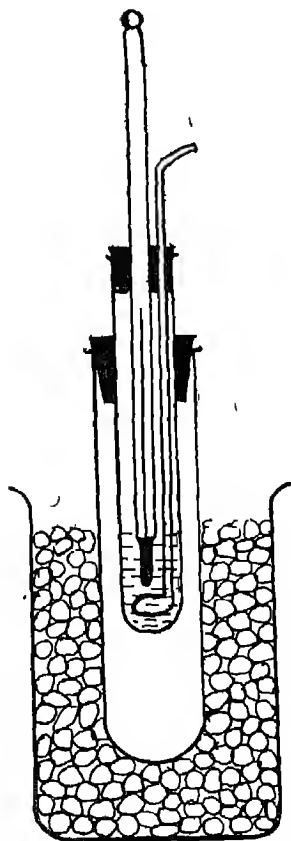


Fig. 5.1

way that the bottom of the test tube should not touch the walls of the boiling tube. Put this assembly in a tin box containing freezing mixture (ice and common salt) as shown in fig. 5.1. Stir the water constantly till the temperature becomes constant ( $t_1^\circ\text{C}$ ). Note this temperature which is the freezing point of pure water.

Weigh one gram ( $w_1\text{g}$ ) of the cane sugar and drop it into the long test tube by removing the rubber cork. Stir the water till whole of the sugar is dissolved. Again fit the test tube into the boiling tube and stir the solution constantly till the temperature becomes constant ( $t_2^\circ\text{C}$ ). Record the observations

Weight of cane sugar  $= w_1\text{g}$

Weight of water  $= w_2\text{g}$

Freezing point of water  $= t_1^\circ\text{C}$

Freezing point of solution  $= t_2^\circ\text{C}$ .

Calculate the depression in freezing point from the above observations ( $\Delta T_F = t_1 - t_2$ )

(B) *Effect of the impurities on the boiling point of water*

Take 10 ml of distilled water in a boiling tube. Close the mouth of the boiling tube with a rubber cork having three holes. Insert a thermometer ( $110^\circ\text{C}$ ), a delivery tube and a glass tube in the rubber cork. The lower end of the delivery tube and the bulb of the thermometer should be dipped in water. However the glass tube should not be dipped into the water.

Now pass steam into the boiling tube through the delivery tube (Fig. 5.2) till the temperature of water becomes constant. Note down the temperature ( $t_1^\circ\text{C}$ ).

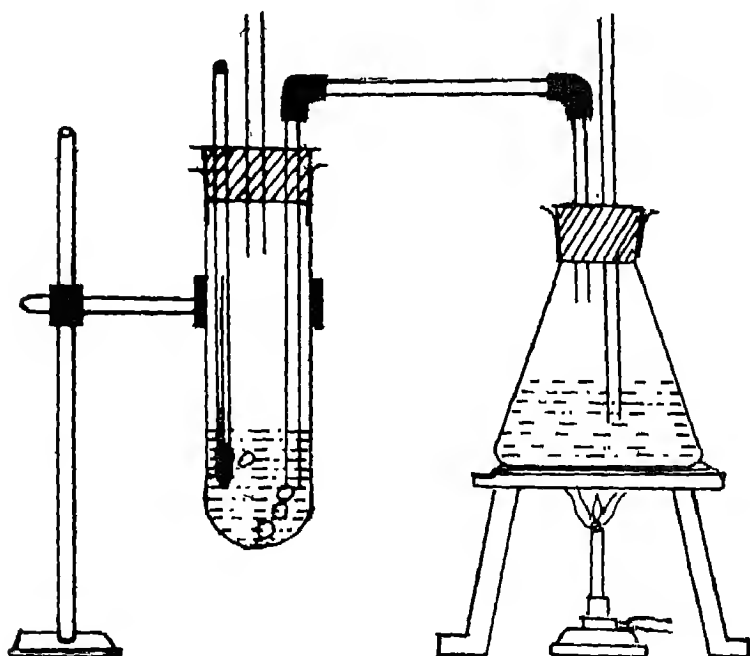


Fig. 5.2



Remove the cork from the boiling tube and add 1 gram ( $w_1$ ) of sodium chloride powder in it. Shake the tube well till the substance is dissolved and fit the cork. Pass steam again into the water to get constant temperature ( $t_2^\circ\text{C}$ ). Read the volume of the solution by using a measuring cylinder (V). Record the observations.

Weight of the sodium chloride	$=w_1 \text{ g}$
Weight of the water	$=w_2 \text{ g}$
Boiling point of water	$=t_1^\circ\text{C}$
Boiling point of solution	$=t_2^\circ\text{C}$

Calculate the elevation in the boiling point of water from the above observations ( $\Delta T_B = t_2 - t_1$ ).

### Remarks

#### Experiment A

1. Water freezes at the temperature when vapour pressure over water and ice becomes equal. When soluble impurity (such as cane sugar) is dissolved in water, the freezing point of water is decreased. This is due to the decrease in the vapour pressure of the solvent. The depression in the freezing point depends upon the number of particles present in the solution. The depression in the freezing point is more in the case of an electrolyte (sodium chloride) whereas, it is less in the case of non electrolyte (cane sugar), provided the weights used are same in both the cases. This is because the number of particles in the case of electrolyte increases due to its ionization.

2. The molecular weight of the dissolved substance can also be determined with the help of the depression in freezing point experiment. The equation used to determine the molecular weight ( $M$ ) is given as :

$$M = \frac{100 \cdot K_F \cdot w_1}{\Delta T_F w_2}$$

where,

$K_F$  = molecular lowering constant (18.58 for water)

$\Delta T_F$  = depression of freezing point.

3. Air gap between the test tube and boiling tube is kept to avoid the supercooling of water.

#### Experiment B

1. When a non-volatile solute (sodium chloride) is dissolved in water, the vapour pressure of water is decreased. Due to the lowering of vapour pressure, the boiling point of water increases.

2 In the presence of the dissolved impurity the vapour pressure of the solvent (water) decreases due to the jamming effect produced by the solute molecules on the solvent molecules. Thus solvent molecules which are attached with the solute molecules require more heat for their separation so that they may reach the surface of the water for vapourization.

3. The elevation in the boiling points is more in the case of an electrolyte (sodium chloride) than that of a non-electrolyte (cane sugar). The molecular weight (M) of the dissolved substance can also be determined with the help of the following equation :

$$M = \frac{100K_b \cdot w_1}{\Delta T_b \cdot w_2}$$

Where  $K_b$  is the molecular elevation constant (5.20 for water)  
 $\Delta T_b$  = elevation in boiling point.

### Precautions

1. Pupils should be instructed to set up the apparatus as shown in fig. 5.1 or 5.2.
2. In case of experiment A, the stirring of the solution should be constant.
3. The thermometer readings should be taken accurately because the difference between the two temperatures is very small.
4. After adding the solute to the solvent (water), the test tubes should be shaken well so that all the solute is dissolved.

## OPTIONAL EXPERIMENT NO. 6

### Objective

Study of the effect of rusting of iron in presence of air, water, acid and alkali.

### Expected learning outcomes

1. Skill of setting apparatus and mixing reagents in appropriate quantities.
2. Understanding the effect of air, water, acid and alkali on rusting.

- 3 Understanding the phenomenon of rusting.
4. Application in preventing rusting by suitable method.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Boiling tubes, test tubes, rubber corks, iron nails (2 cm. long), burner, test tube holder and boiling tube stand.

### Chemicals

Distilled water, dil. HCl, dil. sodium hydroxide solution, anhydrous  $\text{CaCl}_2$ , cotton wool and mustard oil.

### Procedure

Take five well cleaned and dried boiling tubes and mark them A, B, C, D and E. Take 25 pieces of cleaned iron nails (free from rust).

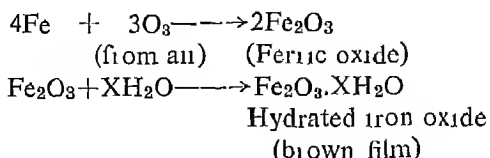
Now place five iron nails in each of the boiling tubes A, B, C and D. In boiling tube A, moist the iron nails with distilled water and close the mouth of the tube with rubber cork. In boiling tube B pour 10 ml of distilled water and boil it for few minutes in order to remove dissolved Oxygen. Now add few ml of the mustard oil slowly from the side of the boiling tube to cover the surface of water. Close the boiling tube with rubber cork. In boiling tube C, add 10 ml of dil. hydrochloric acid solution and close the boiling tube with rubber cork. In boiling tube D, add 10 ml of dil. NaOH solution and close the boiling tube with rubber cork.

In boiling tube E, take a few pieces of anhydrous  $\text{CaCl}_2$  and cover it with a thin layer of cotton wool. Now place five pieces of iron nails on the cotton and make the boiling tube air tight with the help of a cork. Place all these boiling tubes in a stand. Now leave these boiling tubes as such for 4-5 days and observe carefully in which of the boiling tubes iron nails got rusted. Record your observations in a tabular form and draw your conclusions.

### Remarks

1. We find that the rusting of iron nails takes place in the moist air and acid whereas rusting does not take place in sodium hydroxide solution, in water free from oxygen and in dry air.

2. When iron is exposed to moist air, a brown layer on iron is formed. This process is known as rusting. Rusting takes place due to the formation of hydrated ferric oxide,  $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ . Moisture, oxygen and carbon dioxide present in air are responsible for rusting. The reaction is given as follows:



3. When a rusted iron piece is kept for few days in the moist air the rusting spreads quickly, because the little rust formed acts as an auto catalyst, for the rusting process.

4. Rusting is an electro-chemical process. It occurs when a metal finds in its neighbour some species to which it can pass on its electrons. Rusting is aided by the presence of dissolved impurity such as sodium chloride.

5. Rusting may be prevented by coating the surface of iron with paints, oil, grease, etc. It may also be prevented by galvanising the metal.

### Precautions

1. Iron nails taken should be clean and free from rust.
2. Boiling tubes B and E should be air tight.
3. Iron nails in boiling tubes B, C and D should be completely dipped in water, dil. HCl and dil. NaOH solutions, respectively.
4. The boiling tubes should be kept undisturbed during the period of experiment.

## OPTIONAL EXPERIMENT NO. 7

### Objective

Extraction of the essential oils present in the following substances

(a) Sounf (Aniseed) (b) Ajwain (Carum) (c) Illaichi (Cardamom)

### Expected learning outcomes

1. Skill of setting apparatus and mixing the reagents in appropriate amounts.

2. Understanding of the oils present in aniseed, carum and cardamom.
3. Knowledge of extracting oils from the food materials.
4. Application for the preparation of essence of the naturally occurring materials.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Round bottom flask (500 ml), water condenser with receiver, stands with clamps (two), water bath, tripod stand, conical flask (250 ml), wire gauze, burner and thermometer (100°C)

### Chemicals

Aniseed, Carum, Cardamom, Petroleum ether and pumice stone.

### Procedure

Take 100 g. of crushed aniseed in a conical flask and add 100 ml of petroleum ether in it. Close the mouth of the flask with a rubber cork and shake it for some time. Keep the flask for a day. Filter the solution into a distillation flask. Place the flask in a water bath maintained at 75-80° and distill off the petroleum ether (60-80°). Collect the liquid (oil) which is left in the flask in a boiling tube and close the mouth of the boiling tube with a rubber cork. Note the colour, odour and volume of the essential oil so collected. Record the observation in the tabular form.

Similarly essential oil of carum and cardamom can be extracted

### Remarks

1. When crushed aniseed/carum/cardamom is shaken with the petroleum ether, the oil present in these materials get extracted in ether, because most of the organic compounds present in these materials are soluble in petroleum ether.

2. Petroleum ether is volatile and inflammable therefore cold water at good speed should be circulated in the condenser, so that fire accident may not occur.

3. Essential oils are highly non-polar compounds and are esters.

### Precautions

1. For the filtration of the extract, glass wool should be used.
2. Cold water should be circulated in the condenser with a high speed
3. The delivery tube of the condenser should be fitted with the receiver and in turn the receiver tube should be fitted to the recovery flask.
4. Receiving flask should be kept in ice.
5. All the joints of the distillation apparatus should be kept air tight

## OPTIONAL EXPERIMENT NO. 8

### Objective

Analysis of the constituents of the following alloys qualitatively  
(a) brass (b) bronze (c) duralumin.

### Expected learning outcomes

1. Skill of dissolving the alloys.
2. Skill of testing the various metals present in the alloys.
3. Understanding of the contents present in different alloys.
4. Knowledge of preparing different alloys.

### Materials required

(For each pupil or a group of pupils )

### Apparatus

Test tubes, boiling tube, funnel, filter papers, test tube holder, test tube stand, porcelain dish and burner/spirit lamp.

### Chemicals

General and common laboratory reagents.

### Procedure

#### A. Analysis of brass sample/bronze sample

##### STEP I

Take a small piece of the alloy in a porcelain dish and add to it about 10 ml of conc.  $\text{HNO}_3$  (50%). Heat the contents first slowly in a fuming

cupboard or near window till whole of brass is completely dissolved. Now heat strongly to remove excess of  $\text{HNO}_3$ . Cool the contents of porcelain dish and add a few ml of distilled water and dil.  $\text{HCl}$  solution.

## STEP II

Now pass  $\text{H}_2\text{S}$  gas in the acidified solution till you get black precipitate. Filter the precipitate and collect the filtrate in a separate test tube. With the precipitate, test the presence of basic radicals of the II group.

## STEP III

To the filtrate add solid ammonium chloride (about 1 g) and excess of ammonium hydroxide solution till you get the smell of ammonia. Shake the test tube and filter the precipitate. Collect the filtrate in test tube. Test the presence of III group radicals with the precipitate.

## STEP IV

Pass  $\text{H}_2\text{S}$  gas through the ammonical filtrate obtained from step III and filter. Test for the presence of IV group radicals with the precipitate.

## B. Analysis of duralumin sample

Take a small piece of duralumin sample and dissolve it in 10 ml of aquaregia (3 parts conc  $\text{HCl}$  + 1 part conc.  $\text{HNO}_3$ ). Prepare its solution as mentioned above in step I.

Test for the presence of radicals of II group and III group from the precipitates obtained in the respective groups. Record the observations in the tabular form.

## Remarks

1. An alloy is a mixture of two or more metals. When metals in their molten state are mixed together, an alloy is formed. Brass, bronze and duralumin are some common alloys.

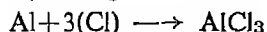
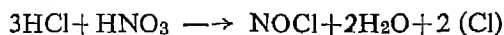
2. The constituents present in brass, bronze and duralumin are given below :

	Alloy	components
(i)	Brass	Cu, Zn, Sn, Pb, and Fe,
(ii)	Bronze	Cu, Sn, small amount of Pb, Fe and Zn.

- (iii) Duralumin Al, Cu, and small amount of Mg and Mn.

3. When brass and bronze are dissolved in nitric acid, the soluble nitrates of the main constituents e.g Cu, Zn, Sn, etc. are formed.

4. Duralumin which contains Cu and Al as main constituents dissolves in aquaregia. The reactions are as follows :



5. While preparing the solution of an alloy for the separation of different constituents, the solution must be heated to dryness, to remove all the nitric acid present in it. In case, it is not removed, it will interfere in qualitative analysis.

### Precautions

1. While dissolving the alloys in acid, heating should be done in the fuming cupboard or near the window.

2. After dissolving the alloy in the acid, the content should be heated.

3. For preparing the solution, the residue should be extracted with dil HCl.

## OPTIONAL EXPERIMENT NO. 9

### Objective

Study of the destructive distillation of wood and its products.

### Expected learning outcomes

1. Skill of setting apparatus.
2. Understanding of the process of destructive distillation.
3. Knowledge of contents present in the wood.



4. Skill of separating the reaction products.
5. Application in extracting the oils (essences) from the wood.

### Materials required

(For each pupil or a group of the pupils.)

### Apparatus

Clay pot with lid (having capacity of 2 litres), wheat flour, katori (250 ml) angithi/stove/burner, separating funnel (100 ml) and beaker.

### Chemicals

Wood (wood shavings or saw dust) litmus paper and sodium bicarbonate.

### Procedure

Take a clay pot (handia) and fill  $\frac{1}{4}$ th of it with weighed amount of wood shavings or saw dust. Place the katori in the middle of the clay pot over the wood. Close the mouth of the pot with the lid and make it air tight by pasting the paste of wheat flour around the joints. Keep the pot over an angithi or burner maintained at low temperature (Fig 9.1). Heat it for about two hours and allow it to cool at room temperature.

After cooling, remove the lid and take out the katori from the pot. Measure the volume of the liquid and then separate it by using a separating funnel (if different layers are obtained). Record the colour and odour of the liquid samples so collected. Test the acidic nature of the liquid with the help of litmus paper and observe the action of the liquid on saturated solution of sodium bicarbonate. Take a small amount of the liquid in the porcelain dish and burn it with the burner flame. Observe the nature of the flame. Weigh the contents of the wood left in the pot. Note its colour and its state.

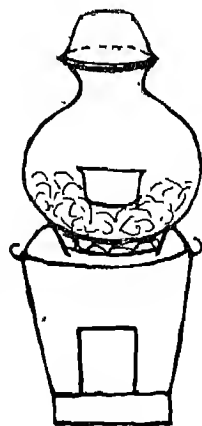


Fig 9.1

### Alternative method

Perform the distillation of wood by taking wood shaving in a hard

glass test tube and setting the apparatus as given in fig 9.2

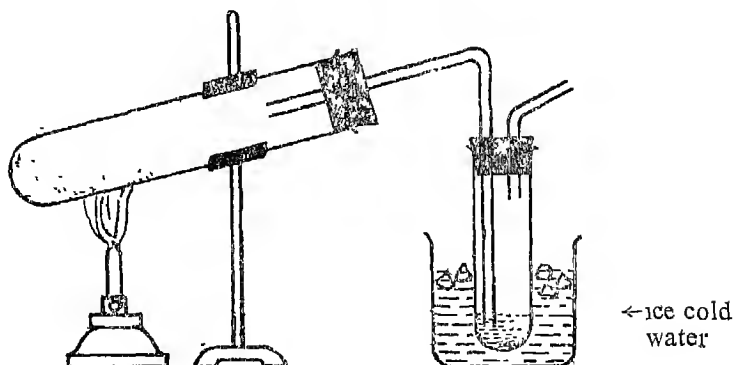


Fig 9.2

### Remarks

1. When the wood shavings are heated in the absence of air, the volatile materials are given out. This process is known as destructive distillation.
2. On cooling the pot the volatile materials are condensed and collected in the katori.
3. The liquid collected in the katori is called pyrolygeneous acid, which contains acetic acid, methanol and small amount of acetone. Water is also present in the liquid.
4. The presence of acetic acid in the liquid is tested by using blue litmus paper. Acetic acid gives effervescence when sodium bicarbonate solution is added in it. This is due to the presence of  $\text{—COOH}$  group.
5. During this process, some gases like  $\text{CH}_4$ ,  $\text{NH}_3$  and  $\text{H}_2\text{S}$  are also evolved.
6. The extract contains a number of organic compounds which are difficult to separate.
7. Wood is composed of polysaccharides which contain cellulose (55-75%), lignin (30%) and also contains small amount of mineral salts, fats, resins and proteins.

### Precautions

1. The apparatus should be made air tight so that the volatile matter may not escape.
2. Heating should be done gently in the beginning and then strongly.
3. The pot should be kept at room temperature for about an hour.

## OPTIONAL EXPERIMENT NO. 10

### Objective

Preparation of aspirin and analysis of its functional groups.

### Expected learning outcomes

1. Skill of weighing and preparing aspirin.
2. Understanding of the chemical reactions taking place during the preparation of aspirin.
3. Skill of preparing crystals of aspirin.
4. Understanding of the process of crystallisation.
5. Skill of testing the functional groups.
6. Applications of the process in preparing other organic compounds.

### Materials required

(For each pupil or a group of pupils.)

### Apparatus

Conical flask (250 ml), water bath and thermometer.

### Chemicals

Salicylic acid (10 grams), acetic anhydride, conc. sulphuric acid, ice and ice cold water.

### Procedure

#### STEP I

#### *Preparation of aspirin*

Take 10 grams of pure dry salicylic acid and 15 grams (14 ml) of acetic anhydride in a conical flask. Add 5 drops of concentrated sulphuric acid to it. Rotate the flask for thorough mixing. Close loosely the mouth of the conical flask with a bark cork and place it in a water bath maintained at 50-60°C for 15 minutes. Shake the flask from time to time. Remove the flask from the water bath and keep it at the room temperature for

cooling. Now pour the mixture slowly with constant stirring over the ice cold water (150 ml). Filter the white precipitate so obtained and wash it with cold water. Dissolve the precipitate in the hot ethyl alcohol and water mixture (20 ml—40 ml) and allow it to cool at room temperature. White needle like crystals separate out. Filter, dry and weigh the sample of the aspirin so obtained and record the yield.

## STEP II

### *Analysis of the functional groups of aspirin*

#### *(A) Test for carboxylic group ( $-\text{COOH}$ )*

(i) Prepare aqueous solution of sodium bicarbonate in a test tube and add a pinch of aspirin to it. Swirl the test tube. Effervescence is observed showing the presence of  $-\text{COOH}$  group.

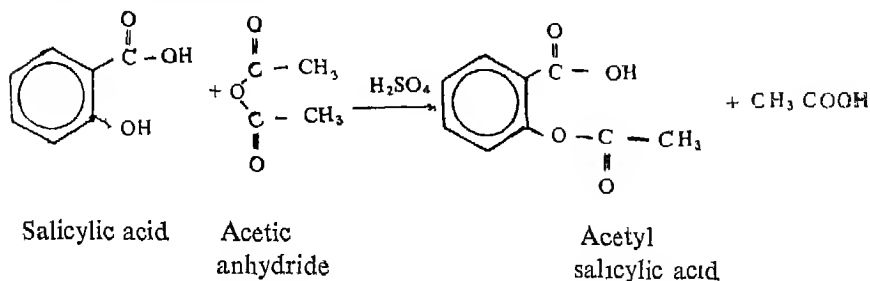
(ii) Prepare aqueous solution of aspirin in a test tube and dip a blue litmus paper in it. The paper is turned red, which confirms the presence of carboxylic group ( $-\text{COOH}$ ) in it.

#### *(b) Test for ester group ( $-\text{OCOCH}_3$ )*

Take 10 ml of NaOH solution in a test tube and add to it a pinch of aspirin. Shake the test tube and boil it till a clear solution is obtained. Cool the solution and acidify it with dil HCl solution. Filter the precipitate so obtained and dissolve it in 4-5 ml of ethyl alcohol. Now add few drops of ferric chloride solution to it. Shake the test tube. Appearance of violet colouration confirms the presence of ester group in the aspirin molecule.

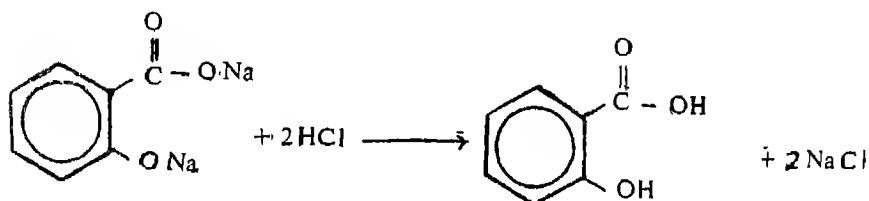
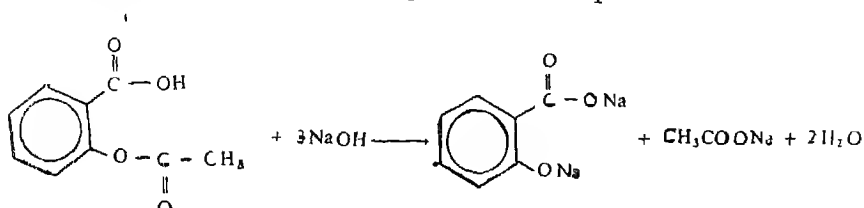
## Remarks

1. When salicylic acid and acetic anhydride are heated in the presence of conc.  $\text{H}_2\text{SO}_4$  (Catalyst), acetyl salicylic acid (Aspirin) is formed. The reaction may be given as follows.

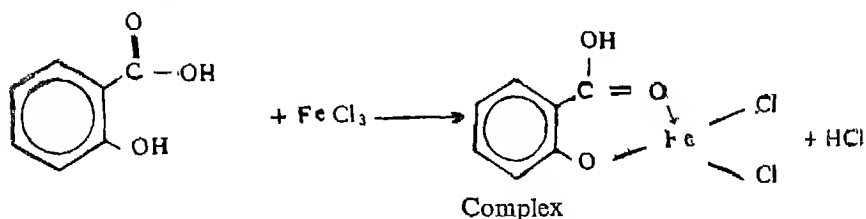


2. Filtration of the acetyl salicylic acid should be done by water suction pump. In case, it is not available ordinary filtration method may be used. Dry the sample between the two folds of filter paper.

3. When aspirin is dissolved in NaOH solution, and the solution is acidified with dil HCl the following reaction takes place.



When ferric chloride solution is added to the above solution the following reaction takes place.



4. While recrystallising, dissolve the sample in hot alcohol and then add water to it. Heat the solution again till all the aspirin is dissolved and then allow it to cool at room temperature.

### Precautions

1. Temperature of the water bath should be maintained at 50°—60°C.
2. Stirring of the mixture should be continuous.
3. After pouring the contents into the ice cold water, it should be shaken well.
4. Melting point of the sample should be determined only after recrystallisation.

## APPENDIX—1

**EXPERIMENTAL COURSE IN CHEMISTRY**  
**FOR CLASSES XI & XII**  
**CLASS-XI**

<i>S. No.</i>	<i>Core Experiments</i>	<i>Periods</i>
1	Acquaintance of chemistry laboratory and basic laboratory techniques (bending, boring, sealing, cleaning of glass apparatus and burner, etc.)	2
2.	Preparation, collection and study of some important physical and chemical properties of at least three gases, one each from the following groups. (a) Chlorine, hydrogen chloride, sulphur dioxide. (b) Carbon dioxide and hydrogen sulphide. (c) Hydrogen, oxygen.	6
3	(a) Preparation of dilute solutions of known concentration of sulphuric acid, hydrochloric acid and nitric acid. (b) Reaction of dilute and concentrated acids on any two metals (magnesium, zinc, copper and iron).	2
4.	Preparation of crystals from impure samples of any two of the following substances, using simple laboratory processes (sedimentation, decantation, filtration and evaporation) alum, copper sulphate, potassium nitrate, ferrous sulphate from kipp's waste.	2
5.	Study of electrical conductivity of water and aqueous solutions of inorganic acids, and bases, sugar, salts and organic liquids.	4
6.	(a) Determination of the pH of following substances by using universal indicator solution or pH paper. (i) soils (ii) acids and bases of different dilutions (iii) vegetable and fruit juices (b) Study of pH change by common-ion effect in case of weak acids and weak bases by above method.	4
7.	Determination of the melting point of a solid substance of low melting point (below 100°C) by glass capillary tube method.	2
8.	Study of solubility of a solid substance in water at different temperature and plotting of solubility curve.	4
9.	Determination of the calorific value of any one of the following substances : methylated spirit, wax, kerosene oil, mustard oil. The above	

- substances will be used as a source of heating to raise the temperature through a definite range of a given quantity of water or by any other suitable method. 2
10. Study of the shift in equilibrium between ferric ions and thiocyanate ions by increasing the concentration of either of them. 2
11. Preparation of commonly used standard (molar) solution of oxalic acid or sodium carbonate. 4
12. Study of acid-base single titration i.e. oxalic acid and sodium hydroxide or hydrochloric acid and sodium carbonate. 8
13. Study of neutralization reaction of sodium hydroxide and hydrochloric acid and a rough estimation of the heat of neutralization by simple calorimetric method. 2
14. Elementary qualitative analysis :  
determination of one cation and one anion radical from the following groups (insolubles to be excluded) 16

*Cations :*

$\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{As}^{3+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Zn}^{2+}$ ,  
 $\text{Mn}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{NH}_4^+$

*Anions :*

$\text{CO}_3^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}^{2-}$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  
 $\text{BO}_3^{3-}$

Total = 60 periods

## CLASS XII

<i>S. No.</i>	<i>Core Experiments</i>	<i>Periods</i>
1.	Preparation of double salt of ferrous ammonium sulphate or potash alum.	2
2.	Study of interaction of metals (any three) with salt solutions and to arrange them according to their activity. Metals and salt solution may be selected from the following : Mg, Zn, Fe, Sn, Pb, Cu.	2
3.	(a) Preparation of the following sols . (i) egg albumin or starch or gum. (ii) ferric hydroxide or aluminium hydroxide. (b) Study of dialysis of starch/egg albumin sol containing sodium chloride through a cellophane/parchment paper (qualitatively) :	2

4. Comparison of the precipitation values of sodium chloride, barium chloride and aluminium chloride for arsenious sulphide sol (qualitatively). 2
5. Comparison of the effectiveness of a number of oils and emulsifying agents in forming emulsion 2
- 6 Study of
  - (a) the effect of concentration on the rate of reaction between sodium thiosulphate and hydrochloric acid.
  - (b) the effect of temperature on the rate of reaction between sodium thiosulphate and hydrochloric acid. 4
7. Study of the effect of catalyst on the reaction between potassium permanganate and oxalic acid. 2
- 8 Separation of the coloured substances by paper chromatography and comparison of their Rf values.
  - (a) mixture of red and blue ink.
  - (b) flower or grass juice. 2
9. Study of some simple reactions of carbohydrates, fats and proteins in pure form and their presence in food stuffs. 4
- 10 (a) Preparation of molar solutions of oxalic acid and ferrous ammonium sulphate.
- (b) Study of redox titrations (single titration)
  - (i) oxalic acid and potassium permanganate.
  - (ii) ferrous ammonium sulphate and potassium permanganate. 8
- 11 Qualitative analysis
 

Determination of two cations and two anions from the given mixture of salt (excluding insoluble, interfering radicals, acid combinations and two cations from the same group).

*Cations :*

$\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{As}^{3+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{NH}_4^+$ .

*Anions :*

$\text{CO}_3^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}^{2-}$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{BO}_3^{3-}$ . 12
12. Detection of N, S and halogens in an organic compound (combination of halogens to be avoided) 4
13. Identification of the following functional groups in aliphatic compounds :
 

Unsaturation, hydroxyl, aldehydic, carboxylic and amino group. 4

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Total = 50 Periods

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### INVESTIGATORY PROJECTS

*(Minimum one to be done from the sample list or outside the list)*

Total Periods=10

1. Study of the diffusion of solids in liquid
2. Determination of the minimum quantity of manganese dioxide required for the preparation of oxygen gas.
3. Determination of the rate of flow of solutions and liquids horizontally.
4. Investigation on the foaming capacity of different washing soaps and the effect of addition of sodium carbonate on it.
5. Study of the contents of different samples of the tea leaves and reasons for the variation in their taste.
6. Determination of the rate of evaporation of different liquids.
7. Study of the effect of metal coupling on the rusting of iron.
8. Study of the effect of acids and bases on the tensile strength of fibres.
9. Analysis of the fruit and vegetable juices for the contents present in them.
10. Preparation of rayon thread from filter paper.

*Note :* Any other investigatory project can be performed which involves about 10 periods of work with the approval of the teacher.

### OPTIONAL EXPERIMENTS

*(In lieu of a project—minimum three to be done)*

Total Periods=10

1. Study of adsorption of acetic acid on charcoal at two different concentrations.
2. Preparation of soap by using different oils and its comparison with the market soap by determining the foaming capacity and cleaning effect.

3. Comparative study of the rate of fermentation of any two of the following substances :  
(a) wheat flour (b) gram flour (c) potato juice (d) carrot juice (e) orange juice (f) apple juice.
4. Study of the digestion of starch by salivary amylase and effect of pH and temperature on it.
5. Determination of the effect of impurities on the freezing point/boiling point of the solvent (water) using  $+110^{\circ}\text{C}$  thermometer of calibration of  $0.1^{\circ}\text{C}$ .
6. Study of the effect of rusting of iron in presence of air, water acid and alkali.
7. Extraction of essential oils present in any one of the following :  
(a) Sounf (Aniseed) (b) Ajwain (Carum) (c) Illachi (Cardamom).
8. Study of the constituents of an alloy—  
(a) brass (b) bronze (c) duralumin.
9. Study of the destructive distillation of wood and study of its products. (saw dust/match stick/wood shavings may be taken).
10. Preparation of aspirin and analysis of functional groups.

**BACKGROUND INFORMATION ABOUT THE INVESTIGATORY PROJECTS****What are projects**

Often in life we are curious to solve a problem. This could be a practical real life problem or of academic nature the solution of which gives a satisfaction of finding something new, something that has been unknown before. We sometimes wish to understand certain natural phenomena or processes through our personal experiences. Often we are curious to establish cause or effect relationship not just in the domain of science but in many other aspects of life

To most of the people doing a science project means completing a display to show how something works or to illustrate some well known principle of science. An investigatory project on the other hand involves a research to understand the unknown to students and begins with a question. Needless to say, to make the project work in science as exciting as possible, we should aim at making our study an investigatory or a mini-research project.

By and large, during investigation the pupil first becomes interested with a natural phenomenon. He then finds out all he can about the phenomenon by exploiting the available resources. When he reaches a frontier of knowledge he asks a question—a question that must be answered by investigation.

A project work differs from routine class experiments since it necessarily makes investigating a single theme through a series of related experiments in a fashion such that, while definite conclusions may be drawn in some cases, in others it may be open ended. It differs from routine experimentation where the procedures are fixed and the nature of relations to be obtained are also known.

A project is thus much more extensive. In some situations the project work may lead to useful relationship of the experimental findings to other related work or some possible applications in practical life, such as growth of crystals, etc.

**How to select a project**

For the higher secondary stage of education, investigatory projects may be undertaken from any area of the course from sciences in which the pupil

is already familiar with. He may also undertake an investigation on some topics included in the syllabus but not covered in full. Of course he will have to build up his/her theoretical background first. The investigation may also be undertaken in an inter-disciplinary area provided the pupil is so interested and the teacher feels competent enough to guide him. Home projects and advanced laboratory work may be undertaken. The projects may be on environmental studies as well.

The choice of the project will also depend upon the facilities available in the school. In any event, lack of the laboratory facilities need not be made an excuse for not taking up project work, since many investigations can possibly be conducted in the environment, through the use of commonly available apparatus and the common laboratory items (as required for the day to day running of the laboratories). However, if the school is better equipped in terms of laboratory and apparatus, the teacher may encourage the pupils to undertake more sophisticated studies. Under all circumstances, the depth of study will not just depend on the equipment available and the corresponding coverage, in the theoretical part, but very much more on the interests, inquisitiveness and efforts of the pupils and the teachers.

The sample projects given in appendix 1, 2, 3 would show how a problem can be identified. Indeed, regardless of his/her background interest, a higher secondary pupil can begin with any natural phenomena and identify a specific project after a period of study and thought.

### **Role of the teacher**

The teacher has a crucial role to play in the investigation being undertaken by the students. First of all, he must be able to prepare the students to take up investigations by motivating them and arousing their curiosity to explore nature, the physical as well as the biological surroundings and related problems. Initially the pupils would have difficulty in identifying and stating the problems, to be investigated. Naturally, the teacher will have to do some real thinking and consult references for the purpose. He should then distribute the titles among the pupils and develop the approach with them during the course. Throughout the course of investigation, teachers may have to help the pupils by providing guidance through the existing literature (whatever is easily available) and to develop a particular laboratory skill, which may be essential for his investigations. During the course of these studies, some pupils may be stuck at a point and may need direction or guidance.

In some cases, a lot of encouragement is to be provided at every stage. The teacher will be able to do this only if he keeps a close watch on the

progress of work and enjoys the confidence of the pupils.

Although the involvement of the teacher is required at all stages of the investigation, it is advisable that the teacher should allow the pupil to take his/her own course and discover his/her own mistakes and provide the needed help only as a last resort. Even this type of assistance should be given through clues and hints. There should be enough opportunity and stimulus for the pupils to think. However, it is expected that the teacher would generally select projects which would cover experimental work, equivalent to the time spent for three optional experiments.

### **Role of the pupil**

The pupil has to bear in mind that he has the responsibility for the completion of the project and that it is his work and not of his teacher. One of the criteria for good project work could be how independently the student conducted the investigations along with how well he has done it. The pupil should know that while the teacher is available for guidance, his independent thinking in terms of planning, execution, interpretation and reporting are constantly under observation by way of evaluation. At this stage the pupil should expect the teacher or any other friend to do the work for him.

### **Presentation of the project report\***

At the end of the project work each pupil will prepare his/her own report of the investigations carried out by him/her. Generally most of the investigations can be reported in the following format

1. Title of the project.
2. Introduction : A statement of the background knowledge of the idea or purpose behind the investigation and the problem to be investigated along with the significance or the relevance of the proposed investigation.
3. The materials used in the investigation should be itemised.
4. Procedure : A detailed description of the experimental procedure actually employed
5. Observations and data : This would be the factual account of the data information gathered by the pupil, based on relevant observations and experiments. As far as possible, this would be in the form of graphs and tables.
6. Discussion and conclusion : In this part the evidence in hand would be discussed in the background of existing knowledge. The salient

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\* The name of the pupil, teacher and the school should be given.

findings should be recalled to link with or contradict the existing findings wherever possible. This should be based on original phenomena rather than being arbitrary. The generalisation and conclusion must correspond with the observations. The conditions under which the observation have been drawn, may be mentioned.

7. Suggestion for further work It is likely that some investigations would pose many more problems than solved.

The pupils may draw attention to a few of these which he considers relevant

8. An acknowledgement of assistance and guidance received may be included where appropriate.

#### 9. References

#### Evaluation of projects

The evaluation of the project should be aimed at :

- Students practical ability
- His/her initiative
- His/her originality
- His/her resourcefulness
- Ability to infer
- Capacity of presenting a report.

For the purpose of actual evaluation at the time of examination, it is suggested that the project work should be evaluated in two parts .

(i) Project report..... 5 marks

(ii) Viva-voce ..... 5 marks

Since the project work would usually be carried out under a supervisor (teacher) the *Project report* should be evaluated by the teacher/supervisor incharge of the project. The viva-voce would be carried out jointly by the External and Internal examiner.

For the distribution of marks for the project report, the following scheme is suggested :

	Marks
1. Formulation of the problem and the effort put in the work	—1
2. Methodology	—1
3. Observation	—1
4. Discussion	—1
5. Educational outcome (further suggestions)	—1

## APPENDIX—III

## PREPARATION OF COMMON LABORATORY REAGENTS

<i>Name of the Reagent</i>	<i>Concentration</i>	<i>Method of preparation</i>
1. Conc sulphuric acid	18M	as supplied.
2. Conc. hydrochloric acid	12M	-do-
3. Conc. nitric acid	16M	-do-
4. Acetic acid (glacial)	11M	-do-
5. Dil. sulphuric acid	2M	Pour 112 ml of conc. sulphuric acid slowly and with constant stirring in 500 ml of distilled water cool and make volume to 1 litre.
6. Dil hydrochloric acid	4M	Add 344 ml of conc. HCl in the distilled water and make up the volume to 1 litre.
7. Dil. nitric acid	4M	Add 248 ml of conc. $\text{HNO}_3$ in the distilled water and make up the volume to 1 litre.
8. Dil. acetic acid	2M	Add 116 ml of glacial acetic acid in distilled water and make up the volume to 1 litre.
9. Ammonia solution	15M	As supplied.
10. Dil. ammonia solution (ammonium hydroxide)	4M	Pour 268 ml of the conc. ammonia solution in distilled water and make up the volume to 1 litre.
11. Ammonium chloride	4M	Dissolve 216 grams of the salt in one litre of water.
12. Ammonium carbonate	2M	Dissolve 100 grams of Ammonium carbonate in 140 ml of conc. ammonia solution and add distilled water to make it 1 litre.
13. Ammonium acetate	3M	Dissolve 231 grams of the salt in 1 litre of distilled water.
14. Ammonium sulphate	1M	Dissolve 132 grams of the salt in 1 litre of distilled water.
15. Ammonium oxalate	0.5M	Dissolve 40 grams of the salt in 1 litre of distilled water.

- |                        |              |  |
|------------------------|--------------|--|
| 16. Ammonium molybdate | 0.5M         | Dissolve 75 grams of the salt in a mixture of 70 ml of conc. ammonia solution and 130 ml of distilled water. Add 200 gms. of ammonium nitrate and dilute it to 1 litre with water. |
| 17. Bromine water      | approx. 0.2M | Add 5 ml of bromine in 100 ml of distilled water shake the mixture, keep it in a dark bottle and decant off the solution as required.  |
| 18. Barium chloride    | 0.2M         | Dissolve 50 grams of the salt in distilled water and make up the volume to 1 litre.  |
| 19. Chlorine water     | —            | Saturate water with chlorine gas and keep the solution in a dark coloured bottle.  |
| 20. Calcium chloride   | 0.2M         | Dissolve 44 grams of the salt in distilled water and make up the volume to 1 litre.  |
| 21. Copper sulphate    | 0.5M         | Dissolve 125 grams of the salt in distilled water. Add few drops of dilute acetic acid and make up the volume to 1 litre.  |
| 22. Cobalt nitrate     | 0.15M        | Dissolve 44 grams of the salt in distilled water and make up the volume to 1 litre.  |
| 23. Dimethyl glyoxime  | 1%           | Dissolve 10 grams of the solid in ethyl alcohol and make up the volume to 1 litre with distilled water   |
| 24. Diphenylamine      | —            | Dissolve 0.5 gram of the solid in 100 ml of concentrated sulphuric acid diluted with 20 ml of water.   |
| 25. Ferric chloride    | 0.5M         | Dissolve 135 grams of the salt in distilled water. Add 15 ml of conc. hydrochloric acid and make the volume to 1 litre.  |
| 26. Ferrous sulphate   | 0.5M         | Dissolve 140 grams of the salt in distilled water containing 10 ml of conc. sulphuric acid and make up the volume to 1 litre.  |



27. Fehling solution (A-Blue) Fehling solution (B-Colourless)	—	Dissolve 35 grams of copper sulphate crystals, in 500 ml of water. Dissolve 175 grams of Sodium potassium tartarate and 70 grams of solid NaOH in distilled water and dilute it to 500 ml.
28. Iodine solution	0.05M	Dissolve 12.7 grams of iodine crystals in distilled water containing 20 grams of potassium iodide.
29. Lime water	—	Dissolve some amount of calcium oxide in distilled water, filter the solution after sometime and keep it in a reagent bottle.
30. Litmus solution (Blue)	—	Dissolve 10 grams of litmus in distilled water and make up the volume to 1 litre.
31. Litmus solution (Red)	—	To the blue litmus solution add about 10 drops of dilute hydrochloric acid.
32. Lead acetate	0.1M	Dissolve 38 grams of the salt in distilled water and make up the volume to 1 litre.
33. Methyl orange		Dissolve 1 gram of the solid in distilled water and make up the volume to 1 litre.
34. Mercuric chloride	0.1M	Dissolve 27 grams of the salt in the water and make up the volume to 1 litre.
35. Nessler's reagent		Dissolve 23 grams of mercuric iodide and 16 grams of potassium iodide in distilled water and make up the volume to 100 ml. Add 150 ml of 4M NaOH solution. Allow it to stand for 24 hours and decant the solution. Solution should be stored in a dark coloured bottle.
36. Potassium chromate	0.2M	Dissolve 40 grams of the salt in distilled water and make up the volume to 1 litre.
37. Potassium dichromate	0.1M	Dissolve 29 grams of the salt in

		distilled water and make up the volume to 1 litre.
38. Potassium iodide	0.2M	Dissolve 33 grams of the salt in water and make up the volume to 1 litre.
39. Potassium thiocyanate	0.2M	Dissolve 20 grams of the salt in distilled water and make up the volume to 1 litre.
40. Potassium permanganate	0.02M	Dissolve 3.2 grams of the salt in distilled water and make up the volume to 1 litre. Heat the solution and filter it.
41. Potassium ferrioyanide	0.1M	Dissolve 40 grams of the salt in distilled water and make up the volume to 1 litre.
42. Potassium ferricyanide	0.2M	Dissolve 65 grams of the salt in distilled water and make up the volume to 1 litre.
43. Phenolphthalein	—	Dissolve 0.25 grams of the solid in 125 ml of ethyl alcohol and then add 125 ml of distilled water.
44. Sodium hydroxide	4M	Dissolve 176 grams of the sodium hydroxide pellets in distilled water and make up the volume to 1 litre
45. Silver nitrate	0.1M	Dissolve 17 grams of the salt in distilled water and make up the volume to 1 litre and store it in a brown coloured bottle.
46. Starch		Prepare paste of about one gram of starch in cold water and drop it in 100 ml of boiling water while stirring. Allow to cool.
47. Disodium hydrogen phosphate	0.1M	Dissolve 36 grams of the salt in distilled water and make up the volume to 1 litre.
48. Sodium nitroprusside	0.03M	Dissolve 1 gram of the solid in 100 ml of distilled water.
49. Sodium cobaltinitrate	0.16M	Dissolve 68 grams of the solid in distilled water and make the volume to 1 litre.
50. Stannous chloride	0.5M	Dissolve 115 grams of salt in 200

51 Yellow ammonium  
sulphide

ml of concentrated hydrochloric acid by heating (if necessary) Add several pieces of metallic tin and make up the volume to 1 litre  
Take about 200 ml of concentrated Ammonia solution in a bottle and saturate it with  $H_2S$  gas. Add 10 grams of flowers of sulphur and shake well untill sulphur is completely dissolved. Dilute the solution to one litre with distilled water.

## APPENDIX—IV

## LIST OF CHEMICALS AND APPARATUS ETC.

<i>Inorganic Chemicals</i>	<i>Grade</i>
1. Acetic acid	Glacial
2. Aluminium chloride	L.R.
3. Aluminium sulphate	L.R.
4. Alum. (potash)	L.R.
5. Ammonium chloride	L.R.
6. Ammonium carbonate	L.R.
7. Ammonium acetate	L.R.
8. Ammonium sulphate	L.R.
9. Ammonium oxalate	L.R.
10. Ammonium molybdate	L.R.
11. Arsenious oxide	L.R.
12. Arsenious sulphide	L.R.
13. Antimony powder	L.R.
14. Bromine	L.R.
15. Barium chloride	L.R.
16. Bismuth nitrate	L.R.
17. Calcium chloride	L.R.
18. Calcium carbonate	L.R.
19. Calcium oxide	L.R.
20. Cadmium chloride	L.R.
21. Cadmium carbonate	L.R.
22. Copper turnings	Ordinary
23. Copper sulphate	L.R.
24. Copper carbonate	L.R.
25. Cobalt nitrate	L.R.
26. Dimethyl glyoxime	L.R.
27. Diphenyl amine	L.R.
28. Ferric chloride	L.R.
29. Ferrous sulphate	L.R.
30. Ferrous sulphide	L.R.
31. Ferrous ammonium sulphate	A.R.
32. Hydrochloric acid	Ordinary
33. Iron nails	Ordinary
34. Iodine	L.R.

35.	Liquor ammonia	L.R.
36.	Lime	Ordinary
37.	Lead metal	Ordinary
38.	Lead acetate	L.R.
39.	Lead nitrate	L.R.
40.	Litmus paper	Ordinary
41.	Marble chips	Ordinary
42.	Magnesium ribbon	Ordinary
43.	Magnesium sulphate	L.R.
44.	Magnesium carbonate	L.R.
45.	Magnesium bromide	L.R.
46.	Manganese dioxide	L.R.
47.	Manganese sulphate	L.R.
48.	Methyl red	L.R.
49.	Methyl orange	A.R.
50.	Sodium ammonium hydrogen phosphate	L.R.
51.	Mercuric chloride	L.R.
52.	Mono-sodium hydrogen phosphate	L.R.
53.	Nitric acid	L.R.
54.	Nickel chloride	L.R.
55.	Potassium bromide	L.R.
56.	Potassium chlorate	L.R.
57.	Potassium dichromate	L.R.
58.	Potassium permanganate	L.R. & A.R.
59.	Potassium sulphate	L.R.
60.	Potassium chromate	L.R.
61.	Potassium ferricyanide	L.R.
62.	Potassium ferrocyanide	L.R.
63.	Potassium nitrate	L.R.
64.	Potassium carbonate	L.R.
65.	Potassium iodide	L.R.
66.	Potassium thiocyanate	L.R.
67.	pH paper & chart	Ordinary
68.	Silver nitrate	L.R.
69.	Sodium chloride	L.R.
70.	Sodium carbonate	L.R.
71.	Sodium hydroxide (flakes)	L.R.
72.	Sodium peroxide	L.R.
73.	Sodium cobaltinitrate	L.R.
74.	Sodium thiosulphate	A.R. & L.R.

75. Sodium tatarate	L.R.
76. Sodium metal	L.R.
77. Sulphur	L.R.
78. Sodium bicarbonate	L.R.
79. Sodium nitro-prusside	L.R.
80. Stannous chloride	L.R.
81. Starch	L.R.
82. Schiff's reagent (or Fuchsin)	L.R.
83. Sodium potassium tartarate	L.R.
84. Sulphuric acid, (commercial)	L.R. & A.R.
85. Tin metal	Ordinary
86. Turmeric powder	Ordinary
87. Zinc (metal granulated)	Ordinary
88. Zinc chloride	L.R.
89. Zinc sulphate	L.R.
90. Universal Indicator solution	L.R.

*Organic Chemicals**Grade*

1. Acetaldehyde	L.R.
2. Acetic acid	L.R.
3. Acetone	L.R.
4. Aniline	L.R.
5. Acetamide	L.R.
6. Acetic anhydride	L.R.
7. Benedict's reagent	L.R.
8. Benzene	L.R.
9. Benzyl alcohol	L.R.
10. Benzyl amine	L.R.
11. Benzoic acid	L.R.
12. Butanol	L.R.
13. Carbolic acid	L.R.
14. Carbon disulphide	L.R.
15. Carbon tetrachloride	L.R.
16. Casein	L.R.
17. Chloroform	L.R.
18. Citric acid	L.R.
19. Chloral hydrate	L.R.
20. Dimethyl glyoxime	L.R.

21. Dimethyl amine	L.R.
22. P-dichlorobenzene	L.R.
23. Di-phenyl amine	L.R.
24. Di-ethyl ether	L.R.
25. Ethyl alcohol	L.R.
26. Ethyl amine	L.R.
27. Formaldehyde	L.R.
28. Formic acid	L.R.
29. Fructose	L.R.
30. Fehling's solution (A & B)	L.R.
31. Glucose	L.R.
32. Glycerol	L.R.
33. Indigo	L.R.
34. Lactose	L.R.
35. Maltose	L.R.
36. Methyl alcohol	L.R.
37. Methyl oxalate	L.R.
38. Methyl orange	L.R.
39. Naphthalene	L.R.
40. $\alpha$ -Naphthol	L.R.
41. Ninhydrin	L.R.
42. Oxalic acid	L.R. & A.R.
43. Petroleum ether	L.R.
44. Phenol	L.R.
45. Phenolphthalein	L.R.
46. 2-4 Dinitro phenyl hydrozine	L.R.
47. Phenyl hydrazine hydrochloride	L.R.
48. Phthalic acid	L.R.
49. Pyrogallol	L.R.
50. Resorcinol	L.R.
51. Salicylic acid	L.R.
52. Starch	L.R.
53. Sucrose	L.R.
54. Succinic acid	L.R.
55. Thiourea	L.R.
56. Urea	L.R.

*Glassware**Make*

1. Beaker (250 ml, 150 ml)	Corning
2. Burette (50 ml)	"
3. Boiling tubes (50 ml)	"
4. Conical flask (250 ml & 150 ml)	"
5. Eudiometer tube (25 ml)	"
6. Funnel (8 cm diameter)	"
7. Flat bottom flask (500 ml & 1 litre)	"
8. Glass rod	Soda glass
9. Gas jar with lid	"
10. Glass tube	"
11. Capillary tube	"
12. Graduated pipette (10 ml & 25 ml)	Corning
13. Hard glass tube	"
14. Ignition tube	Soda Glass
15. Kipp's apparatus	Corning
16. Liebig's condenser	"
17. Medicine dropper	Soda Glass
18. Measuring cylinder (50 ml & 100 ml)	Corning
19. Measuring flask (250 ml)	"
20. Petri dish (8 cm diameter)	"
21. Pipette (one mark 10 ml & 25 ml)	"
22. Round bottom flask (500 ml & 1 litre)	"
23. Reagent bottle (150 ml, 250 ml & 500 ml)	Soda glass
24. Separating funnel (250 ml)	Corning
25. Test tube (15 ml)	"
26. Trough (10"-15" diameter)	Soda glass
27. Thistle funnel	Corning
28. U-tube	"
29. Woulf's bottle (500 ml)	Soda glass
30. Watch glass (9 cm diameter)	Corning
31. Winchester bottle (2½ litre)	"



*Miscellaneous Articles*

1. Ammeter (0-1 amp.)
2. Agar-agar
3. Ajwain
4. Beehive shelf
5. Burette stand (wooden)
6. Brass metal
7. Burette brush
8. Bronze metal
9. Blow pipe
10. Blue ink (good quality)
11. Connecting wires
12. Calorimeter
13. Cork opener
14. Cork boiler sets
15. Charcoal block
16. Charcoal powder
17. Cellophane (Parchment paper)
18. Chemical balance
19. Coconut oil
20. Cork assorted
21. Dalda ghee
22. Duster cloth
23. Dry cell (1.5 volts)
24. Duralumin
25. Electric bulb (holder)
26. Electric bulb (6 volt)
27. Fibres (cotton, silk, rayon, wollen, terylene etc )
28. Fractional weights
29. Filter paper sheets (Whatman's and ordinary)
30. Glazed tile
31. Gelatin
32. Gum
33. Glass wool
34. Gram flour
35. Groundnut oil
36. Illaichi (cardamom)
37. Laboratory stand
38. Kerosene oil
39. Key (one way)

40. Mahuva oil
41. Mustard oil
42. Mortar and Pestle
43. Olive oil
44. Porcelain dish
45. Plastic wash bottle (500 ml)
46. Platinum wire
47. Physical balance
48. Rubber cork—all sizes
49. Rubber tubing
50. Red ink (good quality)
51. Stop watch
52. Scale (100 cm & 50 cm)
53. Standard market soaps
54. Spatula (plastic)
55. Saw dust
56. Spirit lamp
57. Spirit
58. Steel wool
59. Test tube stand (plastic)
60. Threads
61. Tongs
62. Thermometer (0-110°C and of  $\frac{1}{10}$ th division)
63. Test tube brush
64. Test tube holder
65. Thermometer—ordinary (100°C & 200°C)
66. Tripod stand (iron)
67. Tea samples
68. Turpentine oil
69. Wax (paraffin)
70. Wood chips
71. Weight box (for chemical balance)
72. Water bath
73. Water distillation plant
74. Wheat flour
75. Wire gauze (asbestos centre)
76. Yeast powder

